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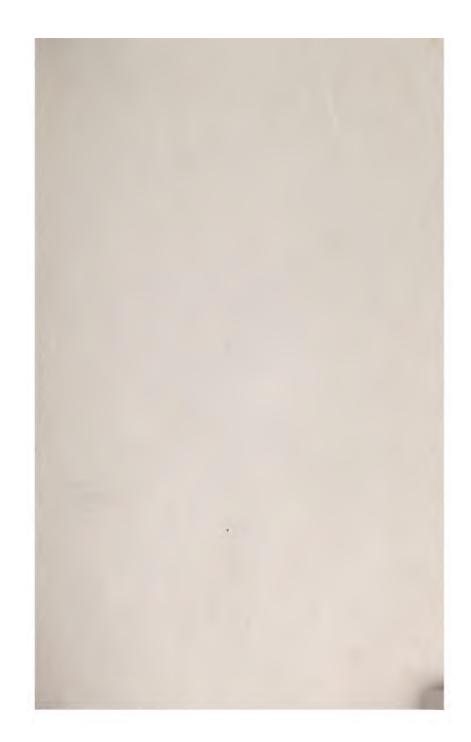
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FIELD PRACTICE

OF

LAYING OUT CIRCULAR CURVES

FOR

RAILROADS.

BY

JOHN C. TRAUTWINE, C. E.,

AUTHOR OF "THE CIVIL ENGINEER'S POCKET-BOOK," "A METHOD OF CALCULATING THE CUBIC CONTENTS OF EXCAVATIONS AND EMBANKMENTS," ETC.

REVISED BY

JOHN C. TRAUTWINE, JR., C.E.

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PREFACE

TO THE

ELEVENTH EDITION.

THE publishers having informed me that they were about to issue a new edition, I endeavored to dissuade them from it, on the plea that the more comprehensive works of Henck, Searles, and Shunk (all of which, in addition to curves, treat on levelling and other field operations) were better adapted to the purposes of young assistants.

Their reply was that the continued demand for my book proved that some persons preferred to have the subject of curves in a portable form, by itself. Therefore, partly on that ground, and partly from a wish to show how some of the more useful problems may be applied to curves exceeding 180°, I assented to a new edition, and, rather hastily, prepared this.

The extension beyond 180° has not, I believe, been hitherto attempted, although its utility has of late years been made evident in the tortuous canyons of our Western States and of Mexico.

The additional matter has nearly doubled the number of pages.

The number of problems might be indefinitely increased by the aid of Euclid, or of any good modern work on geometry; but in fact very few are required in actual practice. Any extraordinary ones that may present themselves can be solved by a drawing. In preparing his drawing for this purpose, the young assistant need not always confine himself to such scales as may be managed by the common dividers; but when, as often happens, only a few chains of the curve need be drawn (including turnouts, etc.), he may with great ease lay them off on the same principle as in field operations, by using his

protractor, and either by long chords, or by tangential and deflection distances and angles; employing a scale of 3 to 12, etc., inches to 100 feet, and filling in the intervals, when required, by the table of ordinates. Even when the preliminaries of a curve have been found by calculation, it generally has to be run two or three times on the ground before it will fit perfectly; therefore a resort to a drawing does not necessarily increase the field work.

The description of the transit, and its adjustments, will, I

trust, be found acceptable.

From Mr. Shunk's excellent "Field Engineer" I have adopted the term "Apex Distance," as preferable to the usual "Tangent Distance."

In Art. 38 I suggest a new mode of easing-off the ends of

curves.

The Table of Natural Versed Sines to 360° will be of use in curves of great arc.

It may prevent embarrassment to state that for what I call the "Tangential" angle, Mr. Henck afterwards adopted "Deflection" angle; and for my "Deflection" angle he employs "Degree of Curve." Mr. Searles adopts Mr. Henck's terms, and Mr. Shunk mine.

In conclusion, owing to nervous prostration, I should not have been able to prepare this edition, but for the efficient aid of my younger son, J. C. T., Jr., upon whom nearly the entire labor devolved, and to whom I consider this acknowledgment due.

Under more favorable circumstances of health and limit of time, it is probable that in some cases neater solutions would have suggested themselves.

JOHN C. TRAUTWINE.

PHILADELPHIA, July, 1882.

PREFACE

TO

FIRST EDITION, 1851.

I HAVE been induced to prepare this little volume almost entirely with reference to the wants of the many young men who desire to qualify themselves for field service in an Engineer Corps. On that account, I have endeavored, by the use of the plainest language, to render the subject intelligible to them,—dispensing with that mathematical brevity which would have better accorded with the requirements of those who have already attained to some degree of proficiency in elementary field operations. Still, I trust that it will not prove unacceptable even to the latter.

The Table of Natural Sines and Tangents to single minutes, in a form sufficiently portable for field use, will supply a want which I have myself frequently experienced, not only in the operation of lay-

ing out curves, but on many other occasions.

One object in preparing it, was to furnish the profession with a Table that should be not only portable, but absolutely reliable. Those whose occupations compel them to resort to the Tables in common use, must have frequently experienced, like myself, the extreme embarrassment which attends the inaccuracies to which they are all subject. So long as a Table is known to contain a single error, the position of which is not ascertained, its employment is attended with doubt in every instance in which we are obliged to refer to it. On this account, I have not only prepared these Tables with the most scrupulous care, while in common type, but in order to render their accuracy a matter of certainty, I had them stereotyped, and afterwards revised three times with the utmost caution. I therefore feel no hesitation in saying that they may be depended upon absolutely. The same remark applies to the other Tables contained in the volume.

As Hassler's and Hutton's Tables of Natural Sines and Tangents are those most in use among the profession, it will be desirable to those persons who possess them to be able to correct the following

errors, which I detected in comparing them.

In Hutton's Tables, Fifth Edition, 1811.

Sine of 6° 8′, for '1063425, read '1068425. Page 328, at top, for 25 Deg., read 40 Deg. Tangent of 44° 60′, for '1000000, read 1'000000. Tangent of 41° 60′, for '8994040, read '9004040.

In Dr. Gregory's Corrected Edition (the 8th) of Hutton's Tables, 1838.

Sine of 49° 14', for '7576751, read '7573751.

In Hassler's Tables, 1830.

Sine of 78° 24', read '9795752. Sine of 20° 60', " '3583679. Sine of 66° 19', " '9157795. Sine of 56° 39', " '8353279. Sine of 55° 20', " '8224751. Sine of 53° 4', " '7993352. Sine of 48° 12', " '7454760. Sine of 45° 3', " '7077236.

It is scarcely necessary to remark that, beyond 44°, the Sines, Tangents, etc., are read *upwards*, from the bottom of the page, using the corresponding column of minutes. To find the sine of an angle exceeding 90°, subtract the angle from 180°, and take out the sine of the remainder—because the sine of an angle, and that of what it wants of 180°, are the same.

John C. Trautwine.

- PHILADELPHIA, 1851.

REMARKS.

The principle upon which railroad curves are laid out, is found in Euclid. It was employed in 1761, in tracing the northern boundary of the State of Delaware. Col. Stephen H. Long, of the U. S. Army, was the first person who reduced it, by means of appropriate rules and tables, to the form now in general use. Professor Rankine, in his "Civil Engineering," claims to have been the first to publish the method in 1843; but states that he had used it in 1841. Col. Long's "Railroad Manual," with full rules and tables for curves, was published early in 1829; and was in general use among Engineers throughout the United States for twelve years before the earliest date claimed by Prof. Rankine. Samuel W. Mifflin, C. E., of Pennsylvania, also published his "Railway Curves," based on the same principle, in 1837.

My first edition was in 1851. Mr. Henck's widely known standard "Field-Book for Railroad Engineers" followed in 1854.

CONTENTS.

| ART. 1.—To lay out a Curve by means of Tangential Angles | PAGE 13 |
|--|------------|
| ART. 2.—To lay out a Curve by means of Deflection Angles | 14 |
| ART. 3.—To lay out a Curve by Eye | 16 |
| Table of Radii, etc | 18 |
| Art. 4.—On Sub-Chords | 21 |
| ART. 5To find Sub-Angles and Sub-Distances exactly | 24 |
| ART. 6.—Ordinates for Entire Chords | 27 |
| ART. 7.—Explanatory | 28 |
| Lengths of Curves; how Measured | 28 |
| Point of Curve. Point of Tangent | 29 |
| Central Angles. Apex Angle | -29 |
| Outer Meeting Angle | 29 |
| Total Deflection Angle | 29 |
| Art. 8.—Substitute Angle. Apex Distance | 30 |
| Relations of Different Angles to each other | 31 |
| Arr. 9.—To find Total Deflection Angles | 33 |
| Art. 10.—To find Radii | 35 |
| ART. 11.—To find Apex Distances | 36 |
| Table of Minutes converted into Decimals of a | |
| Degree | 37 |
| Table of Apex Distances | 38 |
| ART. 12.—To find Tangential and Deflection Angles | 43 |
| ART. 13.—To find Deflection Distances | 45 |
| ART. 14.—To find Tangential Distances | 45 |
| ART. 15.—To find Middle Ordinates | 46 |
| ART, 16.—To find other Ordinates | 47 |
| Art. 17.—To find Ordinates for Sub-Chords | 48 |
| Art. 18.—On Long Chords | 50 |
| Table of Long Chords | 56 |
| Art. 19.—Compound and Reverse Curves defined | 58 59 |
| Arr. 20.—To lay out Compound and Reverse Curves | 60 |
| ART. 21.—To find Radii for Compound Curves | 61 |
| ART. 22.—To find Radii for Compound Curves of 180° Central | 01 |
| Angle | 63 |
| ART. 23.—To find Apex Distances for Compound Curves | 64 |
| Art. 24.—To find Radius for a Reverse Curve | 65 |
| ART. 25.—To change a Curve by Compounding | 66 |
| | 100 |

| | PAGE |
|--|------|
| ART. 26.—To change Parallel Tangents; retaining same | |
| Radius, changing Point of Curve | 68 |
| ART. 27.—To change Parallel Tangents, retaining same Point of Curve, changing Radius | 70 |
| ART. 28.—To change Divergent Tangents; retaining same | |
| Radius, changing Point of Curve and Point of | |
| Tangent | 72 |
| ART. 29To change Divergent Tangents; retaining same | |
| Point of Curve, changing Radius and Point of | |
| Tangent | 74 |
| ART. 30To change Divergent Tangents; retaining same | 100 |
| Point of Tangent, changing Radius and Point | |
| of Curve | 75 |
| ART. 31To change Divergent Tangents; retaining same | |
| Radius and Point of Curve, changing Point | |
| of Tangent | 77 |
| ART. 32To change Parallel Tangents of a Compound Curve; | |
| retaining same Radii and Point of Curve, | |
| changing Point of Compound Curvature | 78 |
| ART. 33To move a Curve from or toward its Apex | 81 |
| ART. 34To find Radius and Central Angle of a Curve re- | |
| quired to clear a certain Point by a given | |
| Distance | 84 |
| ART. 35To find how far from a given Point to start a Curve | |
| of given Radius, in order to clear the Point | |
| by a given Distance | 84 |
| ART. 36.—To find how far a Curve of given Radius will be | |
| from its Tangent, after being run through a | |
| given Angle | 85 |
| Art. 37.—On passing Obstacles | 85 |
| Arr. 38.—On Easing Curves at their Ends | 90 |
| Arr. 39.—On the Resistance of Curves | 92 |
| Table of Resistances | 94 |
| Table for Reduction of Grades on Curves | 95 |
| Coning of Treads of Wheels | 96 |
| Arr. 40.—Elevation of the Outer Rail | 97 |
| Table of Elevations | |
| ART. 41.—On the Equation of Curvature | |
| ART. 42.—Table of Ordinates for Bending Rails | |
| ART, 43,—Description of the Engineer's Transit | |
| Arr. 44.—Adjustments of the Engineer's Transit | |
| To replace Cross-Hairs and Bubble-Glasses Form of Field-Book | |
| Art. 45.—On Sines, Tangents, etc., with Table | |
| Apr. 46.—On Versed Sines with Table | |
| | |

FIELD PRACTICE

oF

LAYING OUT CIRCULAR CURVES

FOR

RAILROADS.

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LAYING OUT CIRCULAR CURVES

FOR

RAILROADS.

CHAPTER I.

PRINCIPLES OF LAYING OUT CURVES.

ARTICLE I.

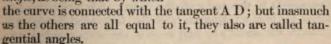
METHOD 1.

To lay out a Curve by means of Tangential Angles.

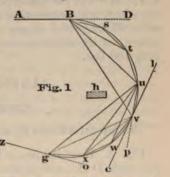
IF from any point B, Fig. 1, in a straight line A D, we

lay off any number of equal angles, as DBs, sBt, tBu, uBv, etc., and at the same time make the chords Bs, st, tu, uv, etc., equal to each other; then the points B, s, t, u, v, etc., will be situated in the circumference of a circle, which is tangential to the line AD at the point B.

The first of these angles, D B s, is called the *tangential* angle, as being that by which



If any obstacle, as h, should prevent our seeing from B farther than to v, the curve may be continued by removing



the instrument to u, the point preceding v; thence sighting first on v, continue to lay off additional tangential angles v u w, w u x, etc., as before. Or else, moving the instrument to v itself instead of to u, sight back to u, and lay off first the exterior angle p v w, equal to double the tangential angle, and afterward continue the tangential angles w v x, x v y, etc., as before, to the end of the curve.

Finally, in order to pass from the end of the curve at g, on to a tangent g z, place the instrument at g, and sighting back to x, lay off the tangential angle x g o; then o g continued toward z will be the required tangent. (See

Art. IV.)

For the tangential angles corresponding to different radii, and chords of 100 feet (the length adopted in this book), see page 18.

Proof of Method 1.—Equal angles, s B t, t B u, etc., at the circumference of a circle, are subtended by equal chords,

st, tu, etc. Euclid.

Remark.—In practice it will be more accurate to remove the instrument to v; sight back to B, and lay off the angle B v l equal to D B v, thus bringing the telescope to sight along v l. Then v l will be a tangent to the curve at v. Revolve the telescope, and it will then sight along v l, which is a continuation of the tangent v l. Then from v lay off tangential angles v v, v v, v v, v v, each 100 feet.

ARTICLE II.

METHOD 2.

To lay out a Curve by means of Deflection Angles.

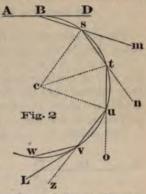
Fig. 2. First, having, as in Method 1, laid off a tangential angle D B s, and measured the chord B s, remove the instrument to the end s of the chord, and make the exterior angle m s t equal to twice the tangential angle, and measure the chord s t; and so on at the other points t, u, v, etc., making each of the exterior angles n t u, o u v, etc., equal to twice the tangential angle, and all the chords equal; then will the points B, s, t, u, v, etc., be in the circum-

ference of a circle which is tangential to the line A D at the point B, as by the first method.

But if, at any of these points, as v, we wish to pass off to

a tangent v L, employ at that point the tangential angle z v L, equal to half the deflection angle z v w. (See Art. IV.)

These exterior angles, included between any chord and the extension of the preceding chord, are called chord deflection angles, or simply deflection angles, or sometimes angles of curvature. In any given circle, the angle of deflection is always precisely double the tangential angle, supposing the chords to



be equal. At page 18, we give tables of the angles corresponding to circles of different radii, embracing the limits of railroad practice; and calculated for chords 100 feet in length, that being the usual length for a measuring-chain

on public works.

Proof of Method 2.—Equal angles, t c u, t c s, etc., at the center of a circle, as well as those at the circumference, are subtended by equal chords, t u, t s, etc.; and the deflection angles, n t u, m s t, etc., are equal to the angles, t c u, t c s, etc., at the center of the circle, subtended by one of the equal chords t u or t s. This angle at the center, so subtended, is called the chord central angle. The tangential angle, being always half the deflection angle, is, of course, always half this central angle. The deflection angle gives the curve its name; thus a 3° , 4° , or 10° curve is one whose deflection angle is 3° , 4° , or 10° .

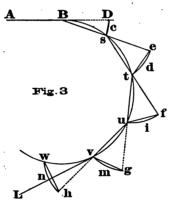
ARTICLE III.

METHOD 3.

To lay out a Curve without a Transit.

The deflection angles, Fig. 3, e s t, f t u, g u v, h v w, etc., being double the tangential angle D B s, the arcs e d t, f i u, g m v, h n w, etc., are double the arc D e s, since the arcs of circles are proportionate to the angles which they subtend; but the chords e t, f u, g v, h w, etc., are not double the chord D e s, since the chords of arcs are not proportionate to the arcs, or to the angles which they subtend.

The chords e t, f u, g v, h w, etc., which subtend the



deflection angles, are called deflection distances; and the chord Ds, which subtends the tangential angle, is called the tangential distance.

But although, in any given circle, the deflection distance is not truly twice the tangential distance, yet the difference is so trifling in large railroad curves, with chords of but 100 feet, that it may be entirely neglected in curves of more than 300 feet radius, as seen in the table, page 18. In that table

the correct length of both will be found for different radii, and for chords of 100 feet.

Having these respective distances, we may frequently trace a curve on the ground by the eye only, with very tolerable accuracy, sufficient for guiding the excavations and embankments, especially on nearly level ground. Suppose, for instance, it be required to lay out in this manner a curve of 5730 feet radius.

First, find by the table, page 18, or by Art. XIII., the deflection distance et, or fu, etc., corresponding to a radius of 5730 feet for a chord of 100 feet, viz., 1.745 feet; and also the tangential distance D $s\cdot872$ of a foot.

Then from the starting point B, and in line with A B, measure B D equal 100 feet; and put a chain-pin at D. Also from B, measure the chord B s, equal 100 feet; at the same time measuring with a graduated rod, from the pin D, the tangential distance D s, equal to 872 of a foot; and place a stake at s. The pin at D may then be removed.

Next, make s e equal 100 feet, placing a pin at e, precisely in line with s B; also from s measure s t equal 100 feet; at the same time measuring with the rod from the pin e, the deflection distance e t, equal to 1.745 feet. Place a stake at t, and remove the pin at e. In this manner proceed to find other points as far as the end of the curve at v.

In order to pass from the curve, as at v, to a tangent v L, proceed as before, only using the tangential distance h n, instead of the deflection distance h w. (See Art. IV.)

This method is abundantly accurate for laying out curves on a canal, or common road; and will occasionally answer very well, when carefully performed, for railroad curves, in the absence of an instrument. Thin straight rods, ironpointed, and a plumb line should be used for ranging the points in the latter case.

Rules for calculating radii, distances, and angles, are

B

given further on.

TABLE OF RADII, Etc.—Chord 100 Feet.

The Tangential Angle is always one-half of the Angle of Deflection.

| Angle of Deflection. | Radius in feet. | Deflection distance in feet. | Tangential distance in feet. | Angle of Deflection. | Radius in feet. | Deflection distance in feet. | Tangentia distance in feet. |
|-------------------------|--------------------|------------------------------------|------------------------------------|-------------------------|--------------------|------------------------------------|-----------------------------------|
| 0 / | OLOHBE | -000 | | 0 / | | 4.000 | .000 |
| 1 | 343775 | .029 | .014 | 44 | 7813 | 1.279 | .639 |
| 2 | 171887 | .058 | :029 | 45 | 7639 | 1.308 | 654 |
| 3 | 114592 | *087 | .043 | 46 | 7473 | 1:337 | *668 |
| 4 | 85944 | .116 | .058 | 47 | 7314 | 1.366 | *683 |
| 5 | 68755 | 145 | .072 | 48 | 7162 | 1.395 | *697 |
| -6 | 57296 | 174 | .087 | 49 | 7016 | 1.424 | .712 |
| 7 | 49111 | .503 | .101 | 50 | 6876 | 1.453 | .726 |
| 8 | 42972 | .232 | '116 | 51 | 6741 | 1.482 | .741 |
| 9 | 38197 | *262 | 131 | 52 | 6611 | 1.513 | .757 |
| 10 | 34377 | 291 | 145 | 53 | 6486 | 1.542 | .771 |
| 11 | 31252 | '320 | '160 | 54 | 6366 | 1.571 | .786 |
| 12 | 28648 | *349 | 174 | 55 | 6251 | 1.600 | .799 |
| 13 | 26444 | '378 | .189 | 56 | 6139 | 1.629 | '815 |
| 14 | 24555 | 407 | .203 | 57 | 6031 | 1.658 | *828 |
| 15 | 22918 | *436 | .218 | 58 | 5927 | 1.687 | *844 |
| 16 | 21486 | 465 | .232 | 59 | 5827 | 1.715 | *857 |
| 17 | 20222 | .494 | *247 | i | 5730 | 1.745 | .872 |
| 18 | 19098 | *523 | *261 | 2 | 5545 | 1.802 | *901 |
| 19 | 18094 | *552 | -276 | 4 | 5372 | 1.862 | .930 |
| 20 | 17189 | *581 | .290 | 6 | 5209 | 1.920 | *959 |
| 21 | 16370 | .610 | *305 | 8 | 5056 | 1.978 | '988 |
| 22 | 15626 | *639 | *319 | 10 | 4911 | 2.036 | 1.018 |
| 23 | 14947 | *668 | *334 | 12 | 4775 | 2.094 | 1.047 |
| 24 | 14324 | '697 | *348 | 14 | 4646 | 2.152 | 1.076 |
| 25 | 13751 | .727 | *363 | 16 | 4523 | 2.210 | 1.105 |
| 26 | 13222 | .756 | .378 | 18 | 4407 | 2.268 | 1.134 |
| 27 | 12732 | .785 | *392 | 20 | 4297 | 2.326 | 1.163 |
| 28 | 12278 | *814 | .407 | 22 | 4192 | 2.384 | 1.192 |
| 29 | 11854 | *843 | *421 | 24 | 4093 | 2.443 | 1.221 |
| 30 | 11459 | .872 | *436 | 26 | 3997 | 2.501 | 1.250 |
| 31 | 11090 | *900 | *450 | 28 | 3907 | 2.559 | 1.279 |
| 32 | 10743 | .930 | *465 | 30 | 3820 | 2.617 | 1:308 |
| 33 | 10417 | 959 | 479 | 32 | 3737 | 2.676 | 1.338 |
| 34 | 10111 | 988 | *494 | 34 | 3657 | 2.734 | 1.367 |
| 35 | 9822 | 1.017 | *508 | 36 | 3581 | 2.793 | 1.396 |
| 36 | 9549 | 1'046 | 523 | 38 | 3508 | 2.851 | 1.425 |
| 37 | 9291 | 1.075 | 537 | 40 | 3438 | 2.908 | 1.454 |
| 38 | 9047 | 1.104 | 552 | 42 | 3370 | 2.967 | 1.483 |
| 39 | 8815 | 1.133 | 566 | 44 | 3306 | 3.025 | 1.512 |
| 40 | 8594 | 1.162 | *581 | 46 | 3243 | 0 0 0 | |
| 41 | 8385 | 1.191 | *595 | 48 | | 3.083 | 1.541 |
| 42 | - | 1.551 | | 50 | 3183 | 3.141 | 1.570 |
| - | 8185 | A SHARK | ·610 | | 3125 | 3'199 | 1.599 |
| 43 | 7995 | 1.50 | 625 | 52 | 3070 | 3.528 | 1.629 |

TABLE OF RADII, Etc.—Chord 100 Feet.

(CONTINUED.)

The Tangential Angle is always one-half of the Angle of Deflection.

| Angle of Deflection. | Radius in feet. | Deflection distance in feet. | Tangential distance in feet. | Angle of Deflection. | Radius in feet. | Deflection distance in feet. | Taugential distance in feet. |
|----------------------|--------------------|------------------------------------|------------------------------------|-------------------------|--------------------|------------------------------------|------------------------------------|
| 0 / | months. | District of | 1 | 0 / | Brank. | | - |
| 1 54 | 3015.7 | 3.319 | 1.658 | 3 20 | 1719.1 | 5.817 | 2.908 |
| 56 | 2963.7 | 3.374 | 1.687 | 22 | 1702.1 | 5.875 | 2.937 |
| , 58 | 2913.5 | 3:432 | 1.716 | 24 | 1685.4 | 5.935 | 2.966 |
| 2 | 2864.9 | 3.490 | 1.745 | 26 | 1669.1 | 5.992 | 2.996 |
| 2 | 2818.0 | 3.548 | 1.774 | 28 | 1653.0 | 6.050 | 3.025 |
| 4 | 2772.5 | 3.606 | 1.803 | 30 | 1637.3 | 6.108 | 3.054 |
| 6 | 2728.5 | 3.665 | 1.832 | 32 | 1621.8 | 6.166 | 3.083 |
| 8 | 2685.9 | 3.723 | 1.861 | 34 | 1606.7 | 6.224 | 3.112 |
| 10 | 2644.6 | 3.781 | 1.890 | 36 | 1591.8 | 6.282 | 3.141 |
| 12 | 2604.5 | 3.839 | 1.919 | 38 | 1577.2 | 6.340 | 3.170 |
| 14 | 2565.6 | 3.897 | 1.948 | 40 | 1562.9 | 6.398 | 3.199 |
| 16 | 2527.9 | 3.956 | 1.978 | 42 | 1548.8 | 6.456 | 3.228 |
| 18 | 2491.3 | 4.014 | 2.007 | 44 | 1535:0 | 6.515 | 3.257 |
| 20 | 2455.7 | 4.072 | 2.036 | 46 | 1521.4 | 6.574 | 3.287 |
| 22 | 2421-1 | 4.130 | 2.065 | 48 | 1508.1 | 6.632 | 3.316 |
| 24 | 2387.5 | 4.188 | 2.094 | 50 | 1495.0 | 6.690 | 3.345 |
| 26 | 2354.8 | 4.246 | 2.123 | 52 | 1482.1 | 6.748 | 3.374 |
| 28 | 2323.0 | 4.305 | 2.152 | 51 | 1469.4 | 6.806 | 3.403 |
| 30 | 2292.0 | 4.363 | 2.182 | 56 | 1457.0 | 6.864 | 3.432 |
| 32 | 2261.9 | 4.421 | 2.210 | 58 | 1444.7 | 6.920 | 3.461 |
| 34 | 2232.5 | 4.479 | 2.239 | 4 28 | 1432.7 | 6.980 | 3.490 |
| 36 | 2203.9 | 4.538 | 2.269 | 5 | 1403.4 | 7.125 | 3.562 |
| 38 | 2176.0 | 4.596 | 2.298 | 10 | 1375.4 | 7.270 | 3.635 |
| 40 | 2148.8 | 4.653 | 2.326 | 15 | 1348.4 | 7.416 | 3.708 |
| 42 | 2122:3 | 4.712 | 2.356 | 20 | 1322.5 | 7.561 | 3.781 |
| 44 | 2096.4 | 4.770 | 2.385 | 25 | 1297.6 | 7.708 | 3.854 |
| 46 | 2071.1 | 4.828 | 2.414 | 30 | 1273.6 | 7.853 | 3.927 |
| 48 | 2046.5 | 4.888 | 2.443 | 35 | 1250.4 | 7.998 | 3.999 |
| 50 | 2022.4 | 4.946 | 2.472 | 40 | 1228.1 | 8.143 | 4.071 |
| 52 | 1998.9 | 5.002 | 2.501 | 45 | 1206.6 | 8.289 | 4.145 |
| 54 | 1975.9 | 5.060 | 2.530 | 50 | 1185.8 | 8.432 | 4.218 |
| 56 | 1953.5 | 5.120 | 2.559 | - 55 | 1165.7 | 8.579 | 4.290 |
| 58 | 1931.5 | 5.176 | 2.588 | 5 | 1146.3 | 8.724 | 4.363 |
| 3 | 1910.1 | 5.235 | 2.618 | 5 | 1127.5 | 8.869 | 4.436 |
| 2 | 1889.1 | 5.293 | 2.646 | 10 | 1109.3 | 9.014 | 4.508 |
| 4 | 1868.6 | 5.351 | 2.675 | 15 | 1091.7 | 9.159 | 4.581 |
| 6 | 1848.5 | 5.411 | 2.704 | 20 | 1074.7 | 9:304 | 4.654 |
| 8 | 1828.8 | 5.468 | 2.734 | 25 | 1058.2 | 9.449 | 4.727 |
| 10 | 1809.6 | 5.526 | 2.763 | 30 | 1042.1 | 9.595 | 4.799 |
| 12 | 1790.7 | 5.584 | 2.792 | 35 | 1026.6 | 9.740 | 4.872 |
| 14 | 1772.3 | 5.642 | 2.821 | 40 | 1011.5 | 9.885 | 4.945 |
| 16 | 1754.2 | 5.700 | 2.850 | 45 | 996.9 | 10.03 | 5.017 |
| 18 | 1736.5 | 5.760 | 2.879 | 50 | 982.6 | 10.18 | 5.090 |

TABLE OF RADII, Etc.-Chord 100 Feet.

(CONTINUED.)

The Tangential Angle is always one-half of the Angle of Deflection.

| Angle of Deflection. | Radius in feet. | Deflection distance in feet, | Tangential distance in feet. | Angle of Deflection. | Radius in feet. | Deflection distance in feet. | Tangential distance in feet. |
|-------------------------|--------------------|------------------------------------|------------------------------------|-------------------------|--------------------|------------------------------------|------------------------------------|
| 0 / | | | | 0 / | | | |
| 5 55 | 968.8 | 10.32 | 5.163 | 12 30 | 459.3 | 21.77 | 10.90 |
| 6 | 955'4 | 10.47 | 5.235 | 45 | 450.3 | 22.21 | 11.12 |
| 5 | 942.3 | 10.62 | 5.308 | 13 | 441.7 | 22.64 | 11.34 |
| 10 | 929.6 | 10.76 | 5.380 | 15 | 433.4 | 23.07 | 11.56 |
| 15 | 917.2 | 10.90 | 5.453 | 30 | 425.4 | 23.51 | 11.77 |
| 20 | 905.1 | 11.04 | 5.526 | 45 | 417.7 | 23.94 | 11.99 |
| 25 | 893.4 | 11.20 | 5.600 | 14 | 410.3 | 24.37 | 12.21 |
| 30 | 881.9 | 11:34 | 5.672 | 15 | 403.1 | 24.81 | 12.43 |
| 35 | 870.8 | 11.48 | 5.744 | 30 | 396.2 | 25.24 | 12.65 |
| 40 | 859.9 | 11.63 | 5.817 | 45 | 389.5 | 25.67 | 12.86 |
| 45 | 849.3 | 11.78 | 5.890 | 15 | 383.1 | 26.11 | 13.08 |
| 50 | 839.0 | 11.92 | 5.962 | 15 | 376.8 | 26:54 | 13.30 |
| 55 | 828.9 | 12.06 | 6.035 | 30 | 370.8 | 26.97 | 13.52 |
| 7 00 | 819.0 | 12.21 | 6.108 | 45 | 364.9 | 27.40 | 13.73 |
| 5 | 809.4 | 12.36 | 6.180 | 16 | 359.3 | 27.83 | 13.95 |
| 10 | 800.0 | 12.50 | 6.253 | 90 | 348.5 | 28.70 | 14.38 |
| 15 | 790.8 | 12.64 | 6.326 | 17 30 | 338.3 | 29.56 | 14.82 |
| 20 | 781.8 | 12.79 | 6.398 | 40.00 | 328.7 | 30.43 | 15.25 |
| 25 | 773.1 | 12.94 | 6.470 | 18 30 | 319.6 | 31.29 | 15.69 |
| 30 | 764.5 | 13.08 | 6.214 | 70000 | 311.1 | 32.15 | 16.12 |
| 35 | 756.1 | 13.52 | 6.616 | 19 30 | 302.9 | 33.01 | DENET |
| 40 | 747.9 | 13.37 | 6.689 | 1000 | 295.3 | 200 | 16.56 |
| 45 | 739.9 | 13.21 | 6.762 | 20 30 | - | 33.87 | 16.99 |
| 50 | 732.0 | 13.66 | 2000 | 21 | 287.9 | 34.73 | 17.43 |
| | | | 6.835 | 22 | 274.4 | 36.44 | 18:30 |
| 8 55 | 724:3 716:8 | 13.80 | 6·907 6·980 | 23 | 262.0 | 38.17 | 19.17 |
| | | 14.38 | - | 24 | 250.8 | 39.87 | 20.04 |
| 15 | 695.1 | | 7.198 | | 240.5 | 41.58 | 20.91 |
| 30 | 674.7 | 14.81 | 7.416 | 25 | 231.0 | 43.28 | 21.77 |
| 9 45 | 655.4 | 15.25 | 7.634 | 26 | | 44.98 | 22.64 |
| 7 | 637.3 | 15.68 | 7.852 | 27 | 214.2 | 46.68 | 23.51 |
| 15 | 620.1 | 16.12 | 8.070 | 28 | 206.7 | 48.38 | 24.37 |
| 30 | 603.8 | 16.55 | 8.288 | 29 | 199.7 | 50.07 | 25.24 |
| 10 45 | 588.4 | 16.99 | 8.506 | 30 | 193.2 | 51.76 | 26.11 |
| | 573.7 | 17.43 | 8.724 | 31 | 187.1 | 53.45 | 26.97 |
| 15 | 559.7 | 17.87 | 8.942 | 32 | 181.4 | 55.13 | 27.83 |
| 30 | 546.4 | 18.30 | 9.160 | 33 | 176.0 | 56.82 | 28.70 |
| 11 45 | 533.8 | 18.73 | 9.378 | 34 | 171.0 | 58.47 | 29.56 |
| The same | 521.7 | 19.17 | 9.596 | 35 | 166.3 | 60.14 | 30.42 |
| 15 | 510.1 | 19.61 | 9.814 | 36 | 161.8 | 61.80 | 31.29 |
| 30 | 499.1 | 20.02 | 10.03 | 37 | 157.6 | 63.46 | 32.15 |
| 0 45 12 | 488.5 | 20.47 | 10.25 | 38 | 153.6 | 65.11 | 33.01 |
| | 478.3 | 20.91 | 10.47 | 39 | 149.8 | 66.76 | 33'87 |
| 15 | 468.6 | 21.34 | 10.69 | 40 | 146.2 | 68.40 | 34.73 |

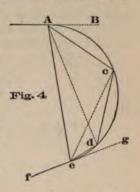
ARTICLE IV.

On Sub-Chords.

We have hitherto spoken of curves as if they were composed of equal chords, each 100 feet in length. It frequently happens, however, that at the end of a curve, as at e, Fig.

4, we are obliged to use a shorter, or sub-chord, de, in order to unite properly with the tangent ef.

In that case, and when using Method 1, Art. I., of laying off curves by means of tangential angles, we must, in order to fix the point e, lay off at A (where the instrument stands), a sub-tangential angle d A e, as much smaller than the entire tangential angle B A c, or c A d, etc., as the sub-hord d e is smaller than an entire 100 feet chord, A c, c d, etc. Thus



if the sub-chord be one-half, or one-fourth, etc., of the entire chord, the sub-tangential angle must be one-half, or

one-fourth, etc., of the entire tangential angle.

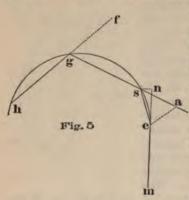
This method is not mathematically exact, for the reason stated in Art. III. (viz., that the *chords* subtending different angles are not proportional to those angles); yet, for curves of 300 or more feet radius, and with chords not exceeding 100 feet in length, the error may be overlooked in practice. Should, however, greater accuracy be required at any time, or for radii less than 300 feet, see Art. V.

In like manner, when we pass off from a sub-chord, as at e, to a second tangent, ef, we must place the instrument at e, and lay off the same sub-tangential angle def gf or, which is better, take sight from e to e, and lay off the angle e e f0, equal to the f1 sum of a tangential and the sub-

tangential angle.

But when using Method 2, Art. II., of deflection angles, or Method 3, Art. III., of deflection distances, we may calculate the sub-deflection angle a s e, Fig. 5, and sub-deflection distance a e, formed between a sub-chord s e, and the extension s a, of an entire chord g s, with sufficient accuracy for curves of 300 or more feet radius, and chords of not more than 100 feet, thus: (for exact method, see Art. V.)

Rule.—Say, as an entire chord of 100 feet is to the subchord s e, so is the *deflection* angle of the curve to a certain angle. Add these two angles together and divide their sum by 2, for the sub-deflection angle a s e, of the sub-chord.



Example.—The curve, Fig. 5, has a radius of 319.6 feet, and an angle of deflection, fgs, of 18° for chords of 100 feet. The sub-chord se is 25 feet in length; what is the sub-deflection angle a se; and also the sub-deflection distance ae, for the sub-chord se?

Here, as 100 is to 25,

So is Def. Ang. of Certain Angle. So is 18° to 4° 30'.

The sum of these two angles, 18° and 4° $30' = 22^{\circ}$ 30', the half of which is 11° 15', the required sub-deflection

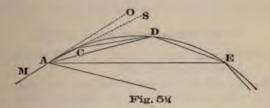
angle a s e, approximately enough.

Again, to find the sub-deflection distance a e, of the subchord s e; take from the table of sines, the natural sine of one-half the sub-deflection angle a s e, just found. Multiply this natural sine by 2, and multiply that product by the length of the sub-chord.

Example.—The sub-deflection angle is 11° 15'; one-half of it is 5° 37½', the tabular natural sine of which is '0979, which, multiplied by 2, gives '1958; and this multiplied by the sub-chord, 25 feet, gives 4'895 feet, the required sub-deflection distance ae, approximately enough.

Finally, to find the sub-tangential distance sn, by means of which to pass from e to the tangent em, say, as 10000 is to the square of the sub-chord in feet, so is the tangential distance for a 100 feet chord, to sn. In this instance, we have as 10000 is to 625, so is 15.69 feet to .980 feet, or sn, approximately. (See Art. V.)

Remark.—Fig. 54. It may be necessary to commence a curve at a point A, which is less than 100 feet from the preceding station M; and in this case it conduces to convenience in drawing the profile of the work, to make the first part of the curve a sub-chord A C, of such a length as will just make up the 100 feet from M. The stations will then coincide with the vertical lines on the engraved profile paper. Although the method of proceeding in this case is extremely simple, and readily deducible from what has been said, still those who have not yet acquired a facility in applying the various modifications will not object to the following illustration:—



Place the instrument at A, Fig. 5½, the commencement of the curve, and first sighting back along the tangent A M, lay off the sub-tangential angle O A C, bearing the same proportion to the entire tangential angle of the curve that the sub-chord A C bears to the entire chord C D of 100 feet. Then with the instrument still remaining at A, continue the curve by laying off entire tangential angles C A D, D A E, etc., and entire chords C D, D E, as usual.

Or if, in consequence of obstructions to the view, the instrument has to be removed to the end C of the sub-chord A C, first sight back to the beginning of the curve at A, lay off a sub-deflection angle S C D = the sum of the sub-tangential angle and an entire tangential angle, making C D an entire chord; and continue the curve as before, with entire tangential angles and chords.

But the following Article, V., contains rules for finding

all these angles and distances exactly.

ARTICLE V.

To find Sub-Tangential Angles exactly.

Rule.—Divide half the sub-chord by the radius. The quotient will be the sine of the sub-tangential angle. Therefore, find in the table of sines, etc., page 124, the sub-tangential angle opposite this sine.

Example.—What is the sub-tangential angle for a sub-

chord of 70 ft.; radius 146:19 ft.?

Here, half the sub-chord is 35 ft.; hence,

 $\frac{35}{146\cdot19}$ = ·2394; and opposite ·2394 in the table of sines, etc., we find 13° 51′, the sub-tangential angle required.

To find Sub-Deflection Angles exactly.

A sub-deflection angle is equal to the chord-tangential

angle + the sub-tangential angle.

Rule.—Divide half the sub-chord by the radius. The quotient will be the sine of the sub-tangential angle. Opposite this sine in the table find the angle itself. Add it to the whole-chord tangential angle.

Example.—What is the sub-deflection angle for a subchord of 70 ft.; radius 146·19 ft.; chord tangential angle

20°?

Here, $\frac{35}{146\cdot 19}$ = $\cdot 2394$ = sine of 13° 51′ = sub-tangential angle.

And $20^{\circ} + 13^{\circ} 51' = 33^{\circ} 51' =$ the sub-deflection

angle required.

To find Sub-Tangential Distances exactly.

Rule.—Divide half the sub-chord by the radius. The quotient will be the sine of the sub-tangential angle. Find this angle. Find the sine of half this angle. Multiply it by 2. Multiply the product by the sub-chord.

Example.—What is the sub-tangential distance for a

sub-chord of 70 ft.; radius 146.19 ft.?

Here, $\frac{35}{146\cdot19}$ = ·2394, or the sine of 13° 51′. Half of

this is 6° $55\frac{1}{2}'$; the sine of which is 1206. And $1206 \times 2 = 2412$. And $2412 \times 70 = 16.884$ ft., the sub-tangential distance required.

To find Sub-Deflection Distances exactly.

Rule.—Divide half the sub-chord by the radius. The quotient will be the sine of the sub-tangential angle. Opposite this sine find the angle itself in the table of sines. Add to this angle a whole-chord tangential angle. The sum will be the sub-deflection angle. Find the sine of half this angle. Multiply this sine by 2. Multiply the product by the sub-chord.

Example.—What is the sub-deflection distance for a 70 ft. sub-chord; radius 146·19 ft.; whole-chord tangential

angle 20°?

Here, $\frac{35}{146\cdot19}$ = '2394 = sine of 13° 51', sub-tangential

And $13^{\circ} 51' + 20^{\circ} = 33^{\circ} 51'$, sub-deflection angle;

half of which = 16° $55\frac{1}{2}'$.

And sine of $16^{\circ} 55\frac{1}{2}^{7} = \cdot 2911$. And $\cdot 2911 \times 2 = \cdot 5822$.

And $.5822 \times 70 = 40.754$ ft., the sub-deflection distance required.

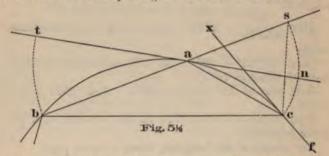
For proofs of the foregoing rules, see next page.

3

Proofs of the Foregoing Rules.

Let b a c, Fig. $5\frac{1}{2}$, be any circular curve; a b a 100 ft. chord; a c a sub-chord; and x f, t n, two tangents to the curve at c and a. Let the whole chord a b be extended, as to s. Then nac, or xca, or abc, is the sub-tangential angle of the sub-chord ac; san, equal to tab, is the tangential angle of the whole chord ab; sac is the sub-deflection angle; a straight line from n to c is the subtangential distance; and sc is the sub-deflection distance.

Of 1st Rule.—Because the angle at the center of the circle, and opposite to half the sub-chord, is equal to the sub-tangential angle. Therefore the sine of the first (which is the one we actually find,) is also the sine of the second.



In any circle, the *half* of any chord, divided by the radius, gives the natural sine of the angle at the center, and opposite to the half-chord.

Of 2d Rule.—It is self-evident that the sub-deflection angle s a c is equal to the chord-tangential angle s a n (= t a b) + the sub-tangential angle n a c.

Of 3d Rule.—The sub-tangential distance is the chord c n of the sub-tangential angle n a c; and, in any circular arc s n c, any chord c n is equal to twice the sine of half the subtended angle $n a c \times radius a c$ of the circle.

Of 4th Rule.—The sub-deflection distance sc is the chord of the sub-deflection angle sac; and, on the same principle as the foregoing, in the circular arc snc, any chord sc is equal to twice the sine of half the subtended angle sac, \times radius ac of the circle.

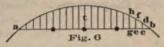
ARTICLE VI.

Ordinates for Entire Chords.

It would be both tedious and liable to inaccuracy to attempt to fix all the necessary points in railroad curves by the foregoing means, which are employed only for entire chords, or for such sub-chords as may be required at the ends of curves.

The best method is to stretch a piece of twine a b, Fig. 6,

100 feet long, between two adjacent chord-stakes, and measure off, as nearly as may be at right angles to it, with



a graduated rod, the previously calculated ordinates cd, ef, gh, etc., placing pegs at d, f, h, etc. On the tops of these stakes, small tacks are driven to define the precise point in the curve. Our table of ordinates, page 50, is calculated for distances apart, bc, ce, eg, etc., of 5 feet; and for all curves likely to occur in practice. The 5 feet distances on the twine should be marked by knots or otherwise; and those at the center, and half way between it and the ends, be further distinguished by tying on pieces

of tape.

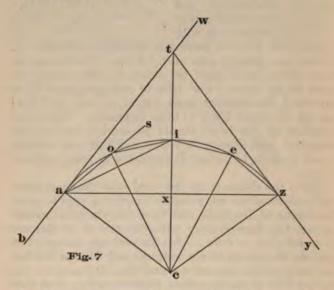
The 5 feet distances are only used (after the excavations and embankments are finished) for placing pegs to guide the laying of the rails, and then only for very sudden curves; for those of large radii, distances of 10 feet are quite sufficient, or even 25 feet for very easy curves. For guiding the curves of the cuttings and fillings, it is not necessary to place the stakes nearer than 50 feet apart; unless for those of less than about 1000 feet radius, when they may be placed 25 feet apart. Ordinates for other radii, or for angles of deflection, intermediate of those in the table, may either be calculated by the rules given further on, or they may be taken proportionally intermediate of the tabular ones, with sufficient accuracy for practice.

To calculate ordinates for chords and sub-chords, see Articles XV., XVI., XVII.

CHAPTER II.

ARTICLE VII.

HAVING shown the general principle on which curves are run, we will now state a few simple elementary points connected with them, with which the young assistant should make himself perfectly familiar before entering upon the problems in Chapter III.



The length of a curve is supposed to be measured, not along its actual curved line or arc, but along the chords. Thus the curve aiz, in Fig. 7, if supposed to have been run with 4 chords of 100 feet each, is said to be 400 feet long, although it is evident that the arc itself is a little longer. But in practice the difference may generally be disregarded; for even in a curve of but 300 feet radius it amounts to only about $5\frac{1}{4}$ inches to a chord of 100 feet; and with 2000 feet radius to but about $\frac{1}{8}$ of an inch.

The length of a curve may also be expressed in degrees of its central angle a c z, contained between two radii c a, c z, drawn from the center c to the ends z and a of the curve. Thus if the curve in Fig. 7 be 4 chains of 25° deflection angle, its central angle a c z will be 25° \times 4 = 100°; and the curve may therefore be said to be 100° long.

The beginning of a curve, or the end first reached in the survey, is called the **Point of Curve**, or *P. C*; and its end is called the **Point of Tangent**, or *P. T*. They are distinguished on the ground by having those letters printed

on the stakes with red chalk.

The field operation is called the tracing, turning, run-

ning, laying out, or staking out of curves.

In Fig. 7, let bt and yt be two tangents touching the ends a and z of any curve (of less than 180° long), and extended to meet at t; and let ac and zc be two radii drawn from the ends of the curve to the center c of the circle. Then the angle acz, subtended by the entire curve a o i ez, is called the central angle of the curve, or the total or entire central angle. This distinguishes it from the small central angle aco, oci, ice, or ecz, subtended by only one chord ao or oi, etc., and which is called the chord central angle, or central angle of a chord. It is generally known at the time, of which of these two angles we are speaking, and therefore the simple term central angle is usually applied to either of them.

The angle a t z, Figs. 7 and 8, between two tangents, t a, t z, is called the apex angle of the curve. If only either one of the tangents is prolonged beyond t, as t a is prolonged to w, then the outer angle w t z, so formed, may be called the **outer meeting angle** of the tangents, inasmuch as it is the *outer* angle at which the two tangents *meet* (not cut, cross, or intersect each other), while the apex angle

atz is the inner meeting one.

The Total Deflection Angle, wtz, Fig. 7 (in distinction from the *chord* deflection angle, soi), denotes the total number of degrees that the line of survey, or of road, deflects from its previous direction; and is equal to the total central angle (a c z, Fig. 7, or n t o, Fig. 30, p. 69) subtended by the whole curve, a iz or n w o. When, as in Fig. 7, the

curve does not exceed 180° , the total deflection angle is the outer meeting angle; but when the curve exceeds 180° , as n w o, Fig. 30, it is what the outer meeting angle, q r h, wants of being 360° ; in other words, it is that angle at r that is subtended by the dotted arc, q y h.

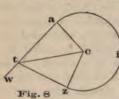
Any chord-central angle a c o, o c i, etc., is equal to the chord-deflection angle s o i; and the total central angle is plainly equal to the chord-deflection angle multiplied by the number of chords in the curve, as well as to the total

deflection angle.

It follows that the chord-deflection angle is equal to the total central angle divided by the number of chords; and that the number of chords is equal to the total central angle divided by the chord-deflection angle.

ARTICLE VIII.

When a curve exceeds 180°, as a iz, Fig. 8, its true cen-



tral angle acz (the large one, subtended by the arc aiz), will, of course, do the same; but we shall at times find it convenient to substitute for it the *small* angle acz, equal to what aiz wants of being 360°. We shall call this the **substitute central angle**, or simply the

substitute angle. It has the same Sine, Tangent, Secant, Cosine, Cotangent, Cosecant and Versed Sine, as the true

central angle.

The tangent distance, or, as Mr. Shunk very aptly calls it, the apex distance, of a curve, is the length $t\,a$ or $t\,z$, Figs. 8 and $8\frac{1}{2}$, of tangent between the end a or z of the curve and the apex t at which the two tangents meet; or, in other words, it is the actual tangent of half the central angle. This tangent distance must not be confounded with the chord tangential distance of Articles III., IV., etc. A tangent merely touches a curve, and cannot cut it; and at the touching point it is at right angles with a radius of the curve. Thus $c\,a\,t$, $c\,z\,t$, are right angles.

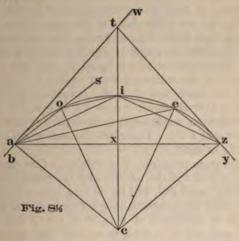
Article XI, shows how to find apex distances.

If we draw a chord az, Fig. 81, between the ends of a

curve; then if we know either the central angle a c z, or the outer meeting angle w t z, we can readily find the three angles a c x, c x a, x a c; for c x a is always 90° ; a c x is

half the central angle; and x a c is $90^{\circ} - a c x$.

To find the length of the chord az, find the sine of half the central angle; multiply it by 2; multiply the product by the radius. The angle tac or tzc, between a radius (ac or zc) and a tangent or apex distance (at or zt), is always 90° .



Referring now to one-half the central angle (say to a c t), a c being radius, a t becomes the actual tangent to a c t; a x its actual sine; x c its actual cosine; x i its actual versed sine; and c t its actual secant. Therefore if we know the actual length of the radius we can find that of any of the others by merely multiplying the radius by the natural tangent, sine, cosine, etc., of the angle a ct. For the table of natural sines, etc., being calculated for an assumed radius of 1, it follows that the actual sines, etc., bear the same proportion to the actual radius that the natural ones bear to the natural radius 1.

Instructions for finding nat sines, etc., by the table, are given on page 123.

Throughout the volume we shall generally omit the

word *natural* before sines, etc.; and in referring to any angle, as *a c t*, Fig. 8½, we shall omit the word *angle*, and call it simply *a c t*, etc.

If any two tangents be drawn to a circle from any one point, as ta, tz, from t, Fig. $8\frac{1}{2}$, they will be of the same

length.

To find ti, first find the secant tc, and from it take the radius ci. Or, ti is $= ta \times$ nat tangent either of tai, or of half taz, or of quarter of wtz, or of quarter of acz. For a proof of this, see demonstration of Article XXI.

In Fig. $8\frac{1}{2}$, az is the chord of the entire curve aiz, and it is plain that either taz or tza is the tangential angle of said chord, or the angle at which it leaves a tangent ta or tz. Hence taz or tza is equal to half the deflection angle wtz, of the entire curve; or to half its central angle acz, in the same way that the tangential angle tas or tas or tas tas tas or tas tas tas or tas ta

On the same principle, if chords a i, z i, be drawn from the ends a and z to the middle i of the entire curve, then t a i, or its equal t z i, will be = i a z, or = i z a; in other words, = half the tangential angle t a z or t z a of the entire curve, or = one-fourth of w t z, or of a c z; and the sum of t a i and t z i is = t a z, or = half the central angle a c z.

If the chords, as ae and ze, are drawn to a point, as e, not in the middle of the curve, the angles tae and tze, between the chords and the tangents, will no longer be equal, but their sum will still be = taz, or = half

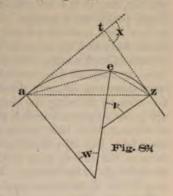
It will be observed that t a i or t z i is = a c o, or = half a c i, or = half i c z; while t a e is = half a c e; and t z e is = half e c z.

The two triangles a t x and c a x, Fig. $8\frac{1}{2}$, will always be similar; that is, they will have the same angles, and be alike in every respect except size.

Therefore, as ac: at::xc:ax, and ::ax:xt; and, as ac:xc::at:ax; and, as ac:ax::at:xt.

Also, in a compound curve a ez, Fig. 83, the sum of

taz + tza is = the sum of the two central angles v+w; or = the total deflection angle x. And if, from the ends of the curve, two chords ae, ze, be drawn to the point e of compound curvature, then is $tae + tze = \frac{1}{2}$ the sum of the two central angles w and v; or = half the outer meeting angle x. This will not hold good if ae and ze be drawn to any other point than that of compound curvature.



ARTICLE IX.

To find the Total Deflection Angle.

This is usually either given by the field notes, or found from the map, in the office. It is defined on page 29; and, as there stated, it is always equal to the total central angle of the curve, whether this be greater or less than 180°.

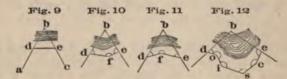
It is equal also to the chord-deflection angle of the curve multiplied by the number of 100 ft, chords contained in the curve.

Or, having the apex distance at, Fig. 8 or $8\frac{1}{2}$, and the radius ac, first find the outer meeting angle, thus: Divide the apex distance by the radius. The quotient is the natural tangent of act, or of half the outer meeting angle. From the table of tangents take the angle corresponding to this nat tangent. Multiply the angle by 2. If the product is 180° , or less, it is at once the total deflection angle; but if it exceeds 180° , take it from 360° . Then the remainder will be the total deflection angle.

The point t. Fig. $8\frac{1}{2}$, is frequently inaccessible, or imaginary, as shown by the point b, Figs. 9 to 12; in which

case no angle at that point can be actually measured. In practice, angles at b are found in the office from the map of the preliminary survey. This map shows the survey to have been made in a series of straight lines, as the undotted lines in Figs. 9 to 12, which Figs. may be regarded as parts of such a map. On the final survey these straight lines or tangents are connected by curves, whose radii, apex distances, etc., are decided upon approximately in the office by drawing the dotted lines d b, b e, and measuring the angle at b with a protractor. The apex angle at b taken from 180° gives the outer meeting angle, or the w t z of Fig. $8\frac{1}{2}$; thus furnishing data on which to determine the radius, apex distances, etc., of the curve by the rules given farther on. The curves are drawn on the map by the dividers or compasses.

Remark.—But owing to trifling errors in chaining, and in measuring angles during the preliminary survey, and to the necessary want of absolute accuracy in the preparation of the map, and in the measurements made from it, the curves thus determined upon in the office rarely, if ever, fit their tangents correctly when they first come to be laid out on the ground. It is to meet this difficulty that many of the usual problems are intended. By their aid the curve can generally be made to fit at the second or third trial.



When there is no local attraction, the directions of the two outer lines in Figs. 9 to 12 may be taken by the compass, and from them the angle at b may be deduced.

Also, if all the other angles have been measured accurately, that at b, Figs. 9 to 12, may be found thus:

Case 1. When the included figure d b e, Fig. 9, has but three sides.

Rule.—Subtract the angle a d e from 180° for the angle b d e; and subtract the angle d e e from 180° for the angle

deb. Add together b de and deb, and subtract their sum from 180° for the angle d b e.

Case 2. When the included figure d b e f, Figs. 10 and

11, has four sides.

Rule.—Subtract the sum of the three internal angles of the figure (marked by dotted portions of circle), from 360° for the angle d b e.

Case 3. When the included figure, 12, has more than

four sides.

Rule.—Add together all the internal angles, marked by dotted portions of circles, and subtract their sum from twice as many right angles as the figure has sides, less

four, for the angle d b e.

Example.—Let the angles denoted by the dotted arcs at the different letters be as follows: That at d, 70°; at o, 220°; at i, 150°; at s, 110°; at c, 160°; at e, 100°. The sum of these is 810°. The figure has seven sides; and twice 7, less 4 = 10; and 10 right angles = 900° ; from which the sum of the designated internal angles (810°) being subtracted, leaves 90° for the angle d b e.

ARTICLE X.

To find the Radius of a Curve.

Rule I.—Divide the apex distance by the tangent of half the central angle; or multiply it by the cotangent of

half central angle.

Rule 2.—Divide half a chord by the sine of half a deflection angle. This applies to equal chords of any given length; or, with any chord, divide half the chord by the sine of half the angle subtended by the chord.

Rule 3.—Approximate only.* Divide 5730 (5729.6) by the deflection angle in degrees and decimals.† This gives 8 of a foot too little for a radius of 500 feet; but

becomes closer as the radius becomes longer.

+ To reduce minutes to decimals of a degree, divide them by 60.

(See Table, p. 37.)

^{*} Because radii are not precisely inversely as their deflection angles; as they would be if those angles, in different curves, were subtended by equal arcs, instead of by equal chords of 100 ft.

Rule 4.—Having a z and x i, Fig. $8\frac{1}{2}$. Then, $Radius = \frac{\text{Square of } half \ a \ z + \text{Square of } x \ i}{\text{Twice } x \ i}.$

This Rule applies to the radius of any circular arc, of

which we know the chord and rise.

Rule 5.—For a track already laid, measure at the rails a chord of 100 feet, and its middle ordinate in feet. Refer to our Table of Ordinates, p. 50, for the deflection angle, opposite which, in table, p. 18, is the radius.

ARTICLE XI.

To find the Apex (or Tangent) Distance of a Curve.

Rule I.—Multiply the radius by the tangent of half the total central angle.

Rule 2.—Use the following Table of Actual Apex Dis-

tances as directed.

Remark.—For the following idea, and table, p. 38, we are indebted to Mr. N. F. Jones, Civ. Eng., whose experience in locating gives great weight to his suggestions; some of which have been incorporated in our rules for curves, without special acknowledgment.

Apex distance = Apex dist. in table p. 38 × given radius required, for given total angle × 5730;

= (approximately) = Apex dist. in table, p. 38 for given total ang. chord deflection angle of given curve, in degrees and decimals.

(See following "Remark.")

If the central angle exceeds 180°, take it from 360°; call the remainder the central (or substitute) angle, and proceed as above.

Example.—What is the apex or tangent distance ta or tz, Fig. 7, p. 28, for a curve aiz of 3° 17′ chord-deflection angle; and with a central angle acz of 88° 10′?

By the first formula. In table p. 19 we find the radius corresponding to a chord-deflection angle of 3° 17′ is 1745.35 feet. In table p. 40, opposite to total central angle 88° 10′, we find 5550. Hence

Apex distance = $5550 \times \frac{1745.35}{5730} = 1690.52$ feet.

By the second (approximate) formula. From table below we find that 3° 17' = 3.°2833. Hence

$$\frac{\text{Apex distance}}{\text{required}} = \frac{5550}{3.2833} = 1690.37 \text{ feet.}$$

The apex distance given by the table for any total central angle is the actual tangent of half that angle for a curve of radius 5730 feet.

Apex distances for total angles intermediate between those given in the table may be obtained by simple proportion; thus:

To obtain the actual apex distance for a 4° curve of 55° 32′ deflection. Here, in the table opposite 55° 30′ find 3015, and for 55° 40′ find 3025, the difference being 10; $_{10}^{2}$ ths of which added to 3015 = 3017, the actual apex dist. of a 1° curve of 55° 32′ deflection, which, divided by 4 = 754, the apex distance required.

If either the central or its substitute angle is between

170° and 180°, use Rule 1, p. 36.

Remark.—If the given chord-deflection angle contains such a number of minutes as cannot be *mentally* reduced to decimals of a degree for dividing by it, use the short table below for making the reduction.

Table of Minutes converted into Decimals of a Degree.

| Min. | Deg. | Min. | Deg. | Min. | Deg. | Min. | Deg |
|------|----------|------|---------|------|---------|------|----------|
| 1 | .016666 | 16 | .266666 | 31 | ·516666 | 46 | .766666 |
| 2 | .033333 | 17 | *283333 | 32 | *533333 | 47 | *783333 |
| 3 | .020000 | 18 | .300000 | 33 | .550000 | 48 | *800000 |
| 4 | .066666 | 19 | *316666 | 34 | •566666 | 49 | *816666 |
| 5 | .083333 | 20 | *333333 | 35 | *583333 | 50 | *833333 |
| 6 | 100000 | 21 | *350000 | 36 | .600000 | 51 | *850000 |
| 7 | ·116666 | 22 | *366666 | 37 | ·616666 | 52 | *866666 |
| 8 | 133333 | 23 | *383333 | 38 | .633333 | 53 | *883333 |
| 9 | 150000 | 24 | *400000 | 39 | *650000 | 54 | .800000 |
| 10 | ·166666 | 25 | 416666 | 40 | .666666 | 55 | .916666 |
| 11 | 183333 | 26 | *433333 | 41 | *683333 | 56 | *933333 |
| 12 | 200000 | 27 | *450000 | 42 | .700000 | 57 | *950000 |
| 13 | ·216666 | 28 | *466666 | 43 | ·716666 | 58 | 966666 |
| 14 | .2333333 | 29 | *483333 | 44 | ·733333 | 59 | *983333 |
| 15 | 250000 | 30 | .200000 | 45 | .750000 | 60 | 1.000000 |

To reduce minutes to decimals of a degree divide them by 60.

TABLE OF ACTUAL APEX DISTANCES.

| Cen. Ang. | Apex D. | Cen. Ang. | Apex D. | Cen. Ang. | Apex D. | Cen. Ang. | Apex D. |
|-----------|------------|-----------|------------|-----------|--------------|-----------|---------|
| 0 / | | 0 / | | ٠, | | 0 / | |
| 1 | 50 | 9 . | 451 | 17 | 856 | 25 | 1270 |
| 10 | 58 | 10 | 460 | 10 | 865 | 10 | 1279 |
| 20 | 66 | 20 | 468 | 20 | 873 | 20 | 1288 |
| 30 | 75 | 80 | 476 | 30 | 882 | 30 | 1297 |
| 40 | 83 | 40 | 485 | 40 | 890 | 40 | 1305 |
| 50 | 92 | 50 | 493 | 50 | 899 | 50 | 1314 |
| 2 | 100 | 10 | 501 | 18 | 908 | 26 | 1323 |
| 10 | 108 | 10 | 510 | 10 | 916 | 10 | 1332 |
| 20 | 117 | 20 | 518 | 20 | 925 | 20 | 1340 |
| 80 | 125 | 30 | 527 | 80 | 933 | 80 | 1349 |
| 40 | 134 | 40 | 535 | 40 | 942 | 40 | 1358 |
| 50 | 142 | 50 | 543 | 50 | 950 | 50 | 1367 |
| 8 | 150 | 11 | 552 | 19 | 959 | 27 | 1376 |
| 10 | 158 | 10 | 560 | 10 | 967 | 10 | 1384 |
| 20 | 167 | 20 | 568 | 20 | 976 | 20 | 1393 |
| 30 | 175 | 80 | 577 | 80 | 984 | 80 | 1402 |
| 40 | 183 | 40 | 586 | 40 | 993 | 40 | 1411 |
| 50 | 192 | 50 | 594 | 50 | 1002 | 50 | 1420 |
| 4 | 200 | 12 | 602 | 20 | 1010 | 28 | 1428 |
| 10 | 209 | 10 | 611 | 10 | 1019 | 10 | 1438 |
| 20 | 217 | 20 | 619 | 20 | 1027 | 20 | 1446 |
| 80 | 225 | 80 | 627 | 30 | 1036 | 80 | 1455 |
| 40 | 233 | 40 | 636 | 40 | 1045 | 40 | 1464 |
| 50 | 242 | 50 | 645 | 50 | 1054 | 50 | 1473 |
| 5 | 250 | 18 | 653 | 21 | 1062 | 29 | 1482 |
| 10 | 258 | 10 | 661 | 10 | 1070 | 10 | 1491 |
| 20 | 267 | 20 | 670 | 20 | 1079 | 20 | 1500 |
| 80 | 275 | 80 | 678 | 80 | 1088 | 80 | 1509 |
| 40 | 284 | 40 | 686 | 40 | 1097 | 40 | 1517 |
| 50 | 292 | 50 | 695 | 50 | 1105 | 50 | 1526 |
| 6 | 300 | 14 | 704 | 22 | 1114 | 80 | 1535 |
| 10 | 308 | 14 10 | 712 | 10 | 1123 | 10 | 1544 |
| 20 | 817 | 20 | 720 | 20 | 1131 | 20 | 1553 |
| 80 | 825 | 80 | 729 | 80 | 1140 | 80 | 1562 |
| 40 | 834 | 40 | 737 | 40 | 1148 | 40 | 1571 |
| 50 | 842 | 50 | 746 | 50 | 1157 | 50 | 1580 |
| 7 | 850 | 15 | 754 | 28 | 1166 | 81 | 1589 |
| 10 | | 10 | | | | 10 | 1598 |
| 20 | 359 367 | 20 | 768 771 | 10 20 | 1175 1183 | 20 | 1607 |
| | | | | | 1100 | | |
| 80 | 875 | 80 | 780 | 30 | 1192 | 80 | 1616 |
| 40 | 384 | 40 | 788 | 40 | 1200 | 40 | 1625 |
| 50 | 893 | 50 | 797 | 50 | 1209 | 50 | 1684 |
| 8 | 401 | 16 | 805 | 24 | 1218 | 82 | 1643 |
| 10 | 409 | 10 | 814 | 10 | 1227 | 10 | 1652 |
| 20 | 417 | 20 | 822 | 20 | 1235 | 20 | 1661 |
| 80 | 426 | 80 | 831 | 30 | 1244 | 80 | 1670 |
| 40 | 434 | 40 | 839 | 40 | 1258 | 40 | 1679 |
| 50 | 442 | 50 | 848 | 50 | 1262 | 50 | 1688 |

TABLE OF ACTUAL APEX DISTANCES-Continued.

| Cen. Ang. | Apex D. | Cen. Ang. | Apex D. | Cen. Ang. | Apex D. | Cen. Ang. | Apex D |
|-----------|---------|-----------|---------|-----------|---------|-----------|--------|
| 0 / | | 0 / | | 0 / | | 0 / | 220 |
| 23 | 1697 | 41 | 2142 | 49 | 2611 | 57 | 3111 |
| 10 | 1706 | 10 | 2152 | 10 | 2621 | 10 | 3122 |
| 20 | 1716 | 20 | 2161 | 20 | 2631 | 20 | 3138 |
| 30 | 1725 | 30 | 2171 | 30 | 2642 | 30 | 3148 |
| 40 | 1734 | 40 | 2180 | 40 | 2652 | 40 | 3154 |
| 50 | 1748 | 50 | 2190 | 50 | 2662 | 50 | 3160 |
| 34 | 1752 | 42 | 2200 | 50 | 2672 | 58 | 3176 |
| 10 | 1761 | 10 | 2209 | 10 | 2682 | 10 | 3187 |
| 20 | 1770 | 20 | 2219 | 20 | 2692 | 20 | 3198 |
| 30 | 1779 | 30 | 2228 | 30 | 2702 | 30 | 3209 |
| 40 | 1788 | 40 | 2238 | 40 | 2713 | 40 | 3220 |
| 50 | 1798 | 50 | 2247 | 50 | 2728 | 50 | 3231 |
| 35 | 1807 | 43 | 2257 | 51 | 2733 | 59 | 3242 |
| 10 | 1816 | 10 | 2267 | 10 | 2744 | 10 | 8258 |
| 20 | 1825 | 20 | 2277 | 20 | 2754 | 20 | 3264 |
| 30 | 1834 | 30 | 2286 | 30 | 2764 | 30 | 3278 |
| 40 | 1843 | 40 | 2295 | 40 | 2774 | 40 | 3286 |
| 50 | 1853 | 50 | 2305 | 50 | 2784 | 50 | 3297 |
| 36 | 1862 | 44 | 2315 | 52 | 2795 | 60 | 3308 |
| 10 | 1871 | 10 | 2325 | 10 | 2805 | 10 | 3319 |
| 20 | 1880 | 20 | 2334 | 20 | 2815 | 20 | 3330 |
| 30 | 1889 | 30 | 2344 | 30 | 2825 | 30 | 3342 |
| 40 | 1899 | 40 | 2354 | 40 | 2836 | 40 | 3358 |
| 50 | 1908 | 50 | 2364 | 50 | 2847 | 50 | 3364 |
| 37 | 1917 | 45 | 2373 | 53 | 2857 | 61 | 3378 |
| 10 | 1926 | 10 | 2383 | 10 | 2867 | 10 | 3386 |
| 20 | 1986 | 20 | 2393 | 20 | 2878 | 20 | 3398 |
| 30 | 1945 | 30 | 2403 | 80 | 2888 | 30 | 3409 |
| 40 | 1955 | 40 | 2412 | 40 | 2899 | 40 | 3420 |
| 50 | 1964 | 50 | 2422 | 50 | 2909 | 50 | 3432 |
| 38 | 1973 | 46 | 2432 | 54 | 2919 | 62 | 3448 |
| 10 | 1983 | 10 | 2442 | 10 | 2930 | 10 | 3454 |
| 20 | 1992 | 20 | 2452 | 20 | 2941 | 20 | 3466 |
| 30 | 2001 | 30 | 2462 | 30 | 2951 | 30 | 3477 |
| 40 | 2010 | 40 | 2472 | 40 | 2962 | 40 | 3488 |
| 50 | 2019 | 50 | 2482 | 50 | 2972 | 50 | 3500 |
| 39 | 2029 | 47 | 2491 | 55 | 2983 | 63 | 3511 |
| 10 | 2039 | 10 | 2501 | 10 | 2993 | 10 | 3525 |
| 20 | 2048 | 20 | 2511 | 20 | 3004 | 20 | 3534 |
| 30 | 2057 | 30 | 2521 | 30 | 3015 | 30 | 3546 |
| 40 | 2067 | 40 | 2531 | 40 | 3025 | 40 | 8557 |
| 50 | 2076 | 50 | 2541 | 50 | 3036 | 50 | 3569 |
| 40 | 2086 | 48 | 2551 | 56 | 3047 | 64 | 3581 |
| 10 | 2095 | 10 | 2561 | 10 | 3058 | 10 | 3592 |
| 20 | 2105 | 20 | 2571 | 20 | 3068 | 20 | 3604 |
| 30 | 2114 | 30 | 2581 | 30 | 3079 | 30 | 3616 |
| 40 | 2124 | 40 | 2591 | 40 | 3090 | 40 | 3627 |
| 50 | 2133 | 50 | 2601 | 50 | 3100 | 50 | 3639 |

TABLE OF ACTUAL APEX DISTANCES-Continued.

| Cen. | Ang. | Apex D. | Cen. Ang. | Apex D. | Cen. Ang. | Apex D. | Cen. Ang. | Apex D |
|------|------|-------------------|-----------|---------|-----------|---------|-----------|--------|
| 0 | 1 | | 0 / | 1 | 0 / | 05 | 0 / | Track. |
| 65 | | 3651 | 73 | 4240 | 81 | 489 | 89 | 5631 |
| | 10 | 3662 | 10 | 4253 | 10 | 4908 | 10 | 5647 |
| | 20 | 3674 | 20 | 4266 | 20 | 4923 | 20 | 5664 |
| : | 30 | 3686 | 30 | 4279 | 30 | 4988 | 30 | 5680 |
| 1 | 40 | 3698 | 40 | 4292 | 40 | 4952 | 40 | 5697 |
| | 50 | 3709 | 50 | 4305 | 50 | 4966 | 50 | 5718 |
| 66 | | 3721 | 74 | 4318 | 82 | 4981 | 90 | 5780 |
| - | 10 | 3733 | 10 | 4331 | 10 | 4995 | 10 | 5747 |
| | 20 | 3745 | 20 | 4344 | 20 | 5010 | 20 | 5768 |
| | 80 | 3757 | 30 | 4357 | 30 | 5025 | 30 | 5780 |
| | 40 | 8769 | 40 | 4870 | 40 | 5040 | 40 | 5797 |
| | 50 | 3781 | 50 | 4383 | 50 | 5054 | 50 | 5814 |
| 67 | 00 | 3793 | 75 | 4397 | 83 | 5069 | 91 | 5831 |
| | 10 | 3805 | 10 | 4410 | 10 | 5084 | 10 | 5848 |
| | 20 | 3817 | 20 | 4424 | 20 | 5099 | 20 | 586 |
| | 30 | 3829 | 50 | 4437 | 30 | 5114 | 30 | 588 |
| | 40 | 3841 | 40 | 4450 | 40 | 5129 | 40 | 589 |
| | 50 | 3853 | 50 | 4463 | 50 | 5144 | 50 | 591 |
| 68 | 00 | 3865 | 76 | 4477 | 84 | | 92 | 598 |
| | 10 | The second second | 10 | | 0.00 | 5159 | | |
| | 10 | 3877 | | 4490 | 10 | 5174 | 10 | 595 |
| | 20 | 3889 | 20 | 4504 | 20 | 5190 | 20 | 596 |
| | 30 | 3902 | 30 | 4517 | 80 | 5205 | 30 | 598 |
| | 40 | 3914 | 40 | 4531 | 40 | 5220 | 40 | 600 |
| | 50 | 3926 | 50 | 4544 | 50 | 5235 | 50 | 602 |
| 69 | | 3938 | 77 | 4558 | 85 | 5250 | 93 | 603 |
| | 10 | 3950 | 10 | 4571 | 10 | 5266 | 10 | 605 |
| | 20 | 3963 | 20 | 4585 | 20 | 5281 | 20 | 607 |
| | 30 | 3975 | 30 | 4599 | 30 | 5297 | 30 | 609 |
| | 40 | 3988 | 40 | 4613 | 40 | 5312 | 40 | 610 |
| | 50 | 4000 | 50 | 4626 | 50 | 5328 | 50 | 612 |
| 70 | 25 | 4012 | 78 | 4640 | 86 | 5343 | 94 | 614 |
| | 10 | 4025 | 10 | 4654 | 10 | 5359 | 10 | 616 |
| | 20 | 4037 | 20 | 4668 | 20 | 5375 | 20 | 618 |
| | 30 | 4049 | 30 | 4681 | 30 | 5390 | 30 | 619 |
| | 40 | 4062 | 40 | 4695 | 40 | 5406 | 40 | 621 |
| | 50 | 4075 | 50 | 4709 | 50 | 5422 | 50 | 623 |
| 71 | | 4087 | 79 | 4723 | 87 | 5438 | 95 | 625 |
| | 10 | 4100 | 10 | 4738 | 10 | 5458 | 10 | 627 |
| | 20 | 4112 | 20 | 4752 | 20 | 5469 | 20 | 629 |
| | 30 | 4125 | 30 | 4766 | 30 | 5485 | 30 | 630 |
| | 40 | 4138 | 40 | 4780 | 40 | 5501 | 40 | 632 |
| | 50 | 4150 | 50 | 4794 | 50 | 5517 | 50 | 634 |
| 72 | | 4163 | 80 | 4808 | 88 | 5533 | 96 | 636 |
| | 10 | 4176 | 10 | 4822 | 10 | 5550 | 10 | 638 |
| | 20 | 4189 | 20 | 4837 | 20 | 5566 | 20 | 640 |
| | 30 | 4201 | 30 | 4851 | 30 | 5582 | 30 | 642 |
| | 40 | 4214 | 40 | 4865 | 40 | 5598 | 40 | 643 |
| | 50 | 4227 | 50 | 4880 | 50 | 5614 | 50 | 645 |

TABLE OF ACTUAL APEX DISTANCES-Continued.

| Cen. Ang. | Apex D. |
|-----------|---------|-----------|---------|-----------|---------|-----------|---------|
| 0 / | 0.455 | 0 / | 7407 | 0 / | 0.055 | 0 / | 10100 |
| 97 | 6477 | 105 | 7467 | 113 | 8657 | 121 | 10128 |
| 10 | 6496 | 10 | 7490 | 10 | 8684 | 10 | 10162 |
| 20 | 6515 | 20 | 7513 | 20 | 8712 | 20 | 10197 |
| 30 | 6534 | 30 | 7536 | 30 | 8740 | 30 | 10232 |
| 40 | 6553 | 40 | 7558 | 40 | 8768 | 40 | 10267 |
| 50 | 6572 | 50 | 7581 | 50 | 8796 | 50 | 10302 |
| 98 | 6592 | 106 | 7604 | 114 | 8824 | 122 | 10337 |
| 10 | 6611 | 10 | 7627 | 10 | 8852 | 10 | 10373 |
| 20 | 6630 | 20 | 7650 | 20 | 8880 | 20 | 10408 |
| 30 | 6650 | 30 | 7674 | 30 | 8908 | 30 | 10444 |
| 40 | 6670 | 40 | 7697 | 40 | 8937 | 40 | 10481 |
| 50 | 6689 | 50 | 7720 | 50 | 8966 | 50 | 10517 |
| 99 | 6709 | 107 | 7744 | 115 | 8994 | 123 | 10553 |
| 10 | 6729 | 10 | 7767 | 10 | 9023 | 10 | 10590 |
| 20 | 6749 | 20 | 7791 | 20 | 9052 | 20 | 10627 |
| 30 | 6768 | 30 | 7815 | 30 | 9081 | 30 | 10664 |
| 40 | 6788 | 40 | 7839 | 40 | 9111 | 40 | 10701 |
| 50 | 6808 | 50 | 7863 | 50 | 9140 | 50 | 10739 |
| 100 | 6829 | 108 | 7887 | 116 | 9170 | 124 | 10777 |
| 10 | 6849 | 10 | 7911 | 10 | 9200 | 10 | 10814 |
| 20 | 6869 | 20 | 7935 | 20 | 9230 | 20 | 10853 |
| 30 | 6890 | 30 | 7960 | 30 | 9260 | 30 | 10891 |
| 40 | 6910 | 40 | 7984 | 40 | 9289 | 40 | 10929 |
| 50 | 6930 | 50 | 8008 | 50 | 9320 | 50 | 10968 |
| 101 | 6951 | 109 | 8033 | 117 | 9351 | 125 | 11007 |
| 10 | 6972 | 10 | 8058 | 10 | 9381 | 10 | 11046 |
| 20 | 6992 | 20 | 8083 | 20 | 9412 | 20 | 11086 |
| 30 | 7013 | 30 | 8108 | 30 | 9442 | 30 | 11125 |
| 40 | 7034 | 40 | 8133 | 40 | 9474 | 40 | 11165 |
| 50 | 7055 | 50 | 8158 | 50 | 9505 | 50 | 11205 |
| 102 | 7076 | 110 | 8183 | 118 | 9536 | 126 | 11246 |
| 10 | 7097 | 10 | 8209 | 10 | 9568 | 10 | 11286 |
| 20 | 7118 | 20 | 8234 | 20 | 9599 | 20 | 11327 |
| 30 | 7140 | 30 | 8260 | 30 | 9631 | 30 | 11368 |
| 40 | 7161 | 40 | 8286 | 40 | 9663 | 40 | 11409 |
| 50 | 7182 | 50 | 8311 | 50 | 9695 | 50 | 11451 |
| 103 | 7204 | 111 | 8337 | 119 | 9728 | 127 | 11493 |
| 10 | 7225 | 10 | 8364 | 10 | 9760 | 10 | 11535 |
| 20 | 7247 | 20 | 8390 | 20 | 9793 | 20 | 11577 |
| 30 | 7269 | 30 | 8416 | 30 | 9825 | 30 | 11619 |
| 40 | 7290 | 40 | 8442 | 40 | 9858 | 40 | 11662 |
| 50 | 7312 | 50 | 8468 | 50 | 9891 | 50 | 11705 |
| 104 | 7334 | 112 | 8495 | 120 | 9925 | 128 | 11748 |
| 10 | 7356 | 10 | 8522 | 10 | 9958 | 10 | 11792 |
| 20 | 7378 | 20 | 8549 | 20 | 9992 | 20 | 11835 |
| 30 | 7400 | 30 | 8576 | 30 | 10025 | 30 | 11880 |
| 40 | 7423 | 40 | 8603 | 40 | 10059 | 40 | 11924 |
| 50 | 7445 | 50 | 8630 | 50 | 10093 | 50 | 11968 |

TABLE OF ACTUAL APEX DISTANCES-Continued.

| Cen. Ang. | Apex D | Cen. Aug. | Apex D. | Cen. Ang. | Apex D. | Cen. Ang. | Apex D. |
|-----------|--------|-----------|---------|-----------|------------|-----------|----------------|
| 0 1 | | 0 1 | | 0 1 | A LOCAL DE | 0 1 | The same |
| 129 | 12013 | 137 | 14546 | 145 | 18173 | 153 | 23867 |
| 10 | 12058 | 10 | 14609 | 10 | 18266 | 10 | 24021 |
| 20 | 12104 | 20 | 14671 | 20 | 18359 | 20 | 24177 |
| 30 | 12149 | 30 | 14735 | 30 | 18454 | 30 | 24334 |
| 40 | 12195 | 40 | 14798 | 40 | 18549 | 40 | 24494 |
| 50 | 12242 | 50 | 14863 | 50 | 18645 | 50 | 24656 |
| 130 | 12288 | 138 | 14927 | 146 | 18742 | 154 | 24819 |
| 10 | 12335 | 10 | 14992 | 10 | 18840 | 10 | 24985 |
| 20 | 12382 | 20 | 15058 | 20 | 18939 | 20 | 25153 |
| 30 | 12429 | 30 | 15124 | 30 | 19039 | 30 | 25323 |
| 40 | 12477 | 40 | 15191 | 40 | 19140 | 40 | 25495 |
| 50 | 12525 | 50 | 15258 | 50 | 19241 | 50 | 25670 |
| 131 | 12573 | 139 | 15326 | 147 | 19344 | 155 | 25846 |
| 10 | 12622 | 10 | 15394 | 10 | 19448 | 10 | 26025 |
| 20 | 12671 | 20 | 15463 | 20 | 19553 | 20 | 26207 |
| 30 | 12720 | 30 | 15532 | 30 | 19659 | 30 | 26391 |
| 40 | 12770 | 40 | 15602 | 40 | 19766 | 40 | 26577 |
| 50 | 12820 | 50 | 15672 | 50 | 19874 | 50 | 26766 |
| 132 | 12870 | 140 | 15743 | 148 | 19983 | 156 | 26958 |
| 10 | 12920 | 10 | 15815 | 10 | 20093 | 10 | 27152 |
| 20 | 12971 | 20 | 15887 | 20 | 20205 | 20 | 27348 |
| 30 | 13022 | 30 | 15959 | 30 | 20317 | 30 | 27548 |
| 40 | 13074 | 40 | 16033 | 40 | 20431 | 40 | 27750 |
| | 13126 | 50 | 16107 | 50 | 20546 | 50 | 27956 |
| 50 | | | 16181 | 149 | 20662 | 157 | 28164 |
| 133 | 13178 | 141 | | | | 10 | |
| 10 | 13231 | 10 | 16256 | 10 | 20779 | 20 | 28375 28589 |
| 20 | 13284 | 20 | 16332 | 20 | 20898 | | |
| 30 | 13337 | 30 | 16408 | 30 | 21017 | 30 | 28807 |
| 40 | 13391 | 40 | 16485 | 40 | 21138 | 40 | 29027 |
| 50 | 13445 | 50 | 16563 | 50 | 21261 | 50 | 29251 |
| 134 | 13499 | 142 | 16641 | 150 | 21385 | 158 | 29478 |
| 10 | 13554 | 10 | 16719 | 10 | 21510 | 10 | 29709 |
| 20 | 13609 | 20 | 16800 | 20 | 21636 | 20 | 29943 |
| 30 | 13664 | 30 | 16880 | 30 | 21764 | 30 | 30181 |
| 40 | 13720 | 40 | 16961 | 40 | 21893 | 40 | 30422 |
| 50 | 13777 | 50 | 17043 | 50 | 22024 | 50 | 30667 |
| 135 | 13833 | 143 | 17125 | 151 | 22156 | 159 | 30916 |
| 10 | 13891 | 10 | 17208 | 10 | 22290 | 10 | 31169 |
| 20 | 13948 | 20 | 17292 | 20 | 22425 | 20 | 31426 |
| 30 | 14006 | 30 | 17377 | 30 | 22562 | 30 | 31687 |
| 40 | 14064 | 40 | 17462 | 40 | 22700 | 40 | 31953 |
| 50 | 14123 | 50 | 17548 | 50 | 22840 | 50 | 32222 |
| 136 | 14182 | 144 | 17635 | 152 | 22982 | 160 | 32496 |
| 10 | 14242 | 10 | 17723 | 10 | 23125 | 10 | 32775 |
| 20 | 14302 | 20 | 17811 | 20 | 23270 | 20 | 33058 |
| 30 | 14362 | 30 | 17901 | 30 | 23417 | 30 | 33347 |
| 40 | 14423 | 40 | 17991 | 40 | 23565 | 40 | 33640 |
| 50 | 14485 | 50 | 18081 | 50 | 23715 | 50 | 33938 |

TABLE OF ACTUAL APEX DISTANCES-Continued.

| Cen. Ang. | Apex D. | Cen. Ang. | Apex D. | Cen. Ang. | Apex D. | Cen. Ang. | Apex D. |
|-----------|------------|-----------|-------------------------------------|-----------|---------|-----------|----------|
| 0 1 | The second | 0 1 | No. of Lot, House, etc., in case of | 0 1 | | 0 / | |
| 161 | 34241 | 166 | 46667 | 171 | 72807 | 176 | 164086 |
| 10 | 34550 | 10 | 47235 | 10 | 74186 | 10 | 171226 |
| 20 | 34864 | 20 | 47817 | 20 | 75618 | 20 | 179014 |
| 30 | 35184 | 30 | 48413 | 30 | 77106 | 30 | 187544 |
| 40 | 35509 | 40 | 49023 | 40 | 78654 | 40 | 196927 |
| 50 | 35840 | 50 | 49649 | 50 | 80265 | 50 | 207298 |
| 162 | 36178 | 167 | 50292 | 172 | 81943 | 177 | 218820 |
| 10 | 36522 | 10 | 50950 | 10 | 83692 | 10 | 231697 |
| 20 | 36872 | 20 | 51626 | 20 | 85517 | 20 | 246184 |
| 30 | 37228 | 30 | 52320 | 30 | 87423 | 30 | 262602 |
| 40 | 37592 | 40 | 53033 | 40 | 89415 | 40 | 281365 |
| 50 | 37963 | 50 | 53765 | 50 | 91500 | 50 | 303014 |
| 163 | 38340 | 168 | 54517 | 173 | 93685 | 178 | 328271 |
| 10 | 38726 | 10 | 55291 | 10 | 95975 | 10 | 358120 |
| 20 | 39118 | 20 | 56086 | 20 | 98380 | 20 | 393938 |
| 30 | 39519 | 30 | 56905 | 30 | 100908 | 30 | 437715 |
| 40 | 39928 | 40 | 57747 | 40 | 103570 | 40 | 492435 |
| 50 | 40345 | 50 | 58615 | 50 | 106374 | 50 | 562789 |
| 164 | 40771 | 169 | 59508 | 174 | 109335 | 179 | 656593 |
| 10 | 41206 | 10 | 60429 | 10 | 112464 | 10 | 787918 |
| 20 | 41650 | 20 | 61379 | 20 | 115778 | 20 | 984903 |
| 30 | 42103 | 30 | 62359 | 30 | 119292 | 30 | 1313211 |
| 40 | 42566 | 40 | 63371 | 40 | 123025 | 40 | 1969823 |
| 50 | 43040 | 50 | 64415 | 50 | 127000 | 50 | 3939655 |
| 165 | 43524 | 170 | 65494 | 175 | 131239 | 180 | Infinite |
| 10 | 44018 | 10 | 66610 | 10 | 135770 | | |
| 20 | 44524 | 20 | 67764 | 20 | 140624 | | |
| 30 | 45041 | 30 | 68958 | 30 | 145838 | | |
| 40 | 45571 | 40 | 70195 | 40 | 151453 | | |
| 50 | 46113 | 50 | 71477 | 50 | 157517 | | |

ARTICLE XII.

Tangential and Deflection Angles.

To find either the Tangential or the Deflection Angle corresponding to any given radius, and to equal chords of any given length.

Rule 1.—Divide half the chord by the radius; the quotient will be the natural sine of the tangential angle. Therefore, the angle corresponding to this sine, in the table of natural sines, will be the tangential angle required; and the tangential angle multiplied by 2 will give the deflection angle.

Example.—Let the radius be 2865 feet, and the chord 100 feet; what will be the tangential and deflection angles?

Here, half the chord (50 feet) divided by the radius (2865 feet), gives 01745; and the tangential angle in the table corresponding to the natural sine 01745 is 1°, twice

which is 2°, the deflection angle required.

Rule 2.—The deflection angle for 100 feet chords may be found approximately (see first foot-note, p. 35) by dividing 5730 by the radius. This is very close for curves of over 500 feet radius. For 500 feet it gives about one minute too little. Or, 343775 divided by the radius will give the deflection angle in minutes; and these divided by 60 will give the angle in degrees and minutes.

Proof.—5730 feet is the radius of a one degree curve; and 343775 feet is the radius of a one minute curve; and the deflection angles of curves are inversely as their radii,

approximately.

Example 1.—What is the deflection angle for a radius

of 2865 feet, the chords being 100 feet each?

Here, 5730 divided by the radius 2865, gives 2°, the deflection angle required.

Example 2.—What is the deflection angle for radius

2022 feet; chords 100 feet?

Here, 5730 divided by 2022 gives the deflection angle 2°.833, or partly in decimals of a degree. Now, in the table on page 37, we see that the decimal 833 of a degree is 50 minutes. Therefore, the required angle is 2° 50', as in our Table of Radii, etc., p. 18.

Example 3.—What is the deflection angle for a radius

of 969 feet?

Here, 343775 divided by 969 gives 355 minutes; and

 $\frac{355}{60} = 5^{\circ}$ 55', the required angle.

Rule 3.—Having only the apex distance, and the total central angle. First find the radius thus: Divide the apex distance by the tangent of half the central angle. Then use Rule 1 of this Article, or Table of Radii, p. 18.

Rule 4.—For a track already laid, measure at the rails a chord of 100 feet, and its middle ordinate in feet. Refer to our Table of Ordinates, p. 50, for the deflection angle.

For sub-tangential and sub-deflection angles, see Arts. IV. and V.

ARTICLE XIII.

Deflection Distances.

To find the Deflection Distance (exactly) for any given radius, and for equal chords of any given length.

Rule 1.—As the radius; the chord; the chord; the deflection distance. Or, in other words, Divide the square of the chord in feet by the radius in feet.

Remark.—For chords of 100 feet, Rule 1 becomes:

Divide 10000 by the radius in feet.

(The deflection distance to a radius of 10000 feet, with chords of 100 feet, is 1 foot; and the deflection distances for other radii increase *inversely* as the radii.)

Example.—What is the deflection distance for a radius

of 5730 feet, the chords being 100 feet long?

Here, 10000 divided by 5730 radius, gives 1.745 feet,

the deflection distance required.

Rule 2.—Divide half the given chord by radius; the quotient will be the natural sine of one-half the deflection angle. Multiply double this natural sine by the chord. The product will be the deflection distance required. By this rule our table was prepared.

Example.—As before, what is the deflection distance to a radius of 5730 feet, the chords being 100 feet long?

Here, half the chord (50 feet) divided by radius (5730 feet) gives '008726, which is the natural sine of half the deflection angle. Now '008726 multiplied by 2, gives '017452, which, multiplied by the chord (100 feet), gives 1.745 feet, the required deflection distance, the same as in the preceding example.

ARTICLE XIV.

Tangential Distances.

To find (exactly) the Tangential Distance corresponding to any given radius, and to equal chords of any given length.

Rule.—First find the tangential angle by Art. XII., and take from the table of natural sines, that corresponding to one-half of the tangential angle. Then multiply double

this sine by the given chord, for the tangential distance. By this rule our table was prepared.

Example.—Let the radius be 2865 feet, and the chords 100 feet each; what will be the tangential distance?

Here, we find, by Art. XII., the tangential angle 1°

for a radius of 2865 feet.

The natural sine corresponding to 30 minutes, or one-half of this tangential angle, is, by the table of sines, '008727; the double of which is '017454, which, multiplied by the chord, or 100 feet, gives 1.745 feet for the tangential distance required.

ARTICLE XV.

Ordinates.

To find the Middle Ordinate to any given radius, and to any given chord.

Rule I.—From the square of the radius subtract the square of *half* the chord. Find the square root of the remainder. Take this square root from the radius.

Example.—What is the length of the middle ordinate de, Fig. 13, the radius ca being 819 feet, and the chord

ab 100 feet?

Here, the square of e a (819) is 670761, and the square of a e (50) is 2500; which, being subtracted from the former, leaves 668261; the square root of which is e c, 817·472; which, taken from the radius 819, leaves 1·528 feet, the required middle ordinate d e.

Rule 2.—With any chord the middle ordinate is equal to the radius multiplied by nat versed sine of half the

angle subtended by the chord.

With chords of 100 feet this becomes: Middle ordinate is equal to radius multiplied by nat versed sine of tangential angle.

Rule 3.—With any chord the middle ordinate is equal to half the chord multiplied by nat tangent of quarter the

angle subtended by the chord.

With chords of 100 feet this becomes: Middle ordinate is equal to *half* the chord multiplied by nat tangent of quarter the deflection angle. Rule 4.—Approximate. With radius 500 feet or more, divide the square of half the chord by the diameter of the curve. When the chord is 100 feet this becomes:

Twice radius

With 300 feet radius this rule gives 030
too short in 4·197 feet; and with 100 feet radius ·897
short in 13·397. See also Rule 2, next Article.

Rule 5.—For 100 ft. chords. Approximate. With radius 500 feet or more, divide the tangential distance by 4.

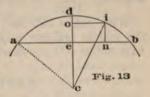
With 300 ft. radius this rule gives but 013 of a foot too short in 4·197 feet; and with 100 radius 456 too short in 13·398.

ARTICLE XVI.

Having given the Middle Ordinate d e, Fig. 13, it is required to find any other one, as i n.

Rule 1.—Subtract the middle ordinate de from the

radius dc; the remainder will be ec: then from the square of the radius ci subtract the square of the distance oi, which the required ordinate in is from the middle ordinate de, and extract the square root of the remainder. This square root will be oc.



From this square root o c subtract e c; the remainder will be o e, which is equal to i n the required ordinate.

Example.—The middle ordinate de, of a 100 ft. chord ba, to a radius of 819, being 1.528 feet, it is required to find the length of the ordinate in, 20 feet from the middle one.

Here, the middle ordinate de, 1·528, subtracted from the radius 819, leaves ee, 817·472. The square of the radius is 670761; and the square of 20 (the distance of the required ordinate from the middle one) is 400; which, taken from 670761, leaves 670361; the square root of which is 818·756, or oe; from which take ee, or 817·472, and the remainder, 1·284, will be oe, which is equal to ie n, the required ordinate.

Rule 2.—Approximate. With radius not less than 500 feet, chords 100 feet, multiply *any* ordinate of a 1° curve (Table, p. 50) by the chord-deflection angle (in degrees and decimals, table, p. 37) of the new curve. The product will be the corresponding new ordinate.

For 300 ft. radius this rule gives middle ordinate '013 foot too short in 4:197 feet; and for 100 radius '318 too

short in 13:398 feet.

Rule 3.—Any ordinate for chords not exceeding 100 feet in length, and for radii not less than 500 feet, may be found near enough for practice, thus: Divide the rectangle of the segments of the chord by the diameter of the curve.

Example.—What is the ordinate at 15 feet from the end

of the 100 feet chord, for a radius of 819 feet?

Here, the ordinate divides the chord into 2 segments, of 15 and 85 feet. The rectangle of these, or 15×85 , is 1275. The radius being 819, the diameter is 1638; con-

sequently $\frac{1275}{1638}$ = .778 feet, the required ordinate.

With radius 300 feet, chord 100 feet, this rule makes the middle ordinate only 030 too short in 4·197; and with radius 100, too short ·897 in 13·397 feet.

ARTICLE XVII.

To find Ordinates for Sub-Chords.

These must be calculated as they are needed. It would not be possible to give tables for all supposable cases. They may be found approximately enough for railroad practice, for curves of over 300 ft. radius, and for chords

not exceeding 100 feet, thus:

The sub-chord being supposed to be divided into the same number of equal parts as the whole chord, then in any circle of given radius, not less than about 300 feet, the ordinates of an entire 100 ft. chord may be assumed to be to those of a sub-chord, as the square of the chord is to the square of the sub-chord.

In all our tables the chord is supposed to be 100 feet,

the square of which is 10000; the rule therefore becomes, as 10000 feet; square of sub-chord in feet; Ord. of

Chord: Ord. of Sub-chord approximately.

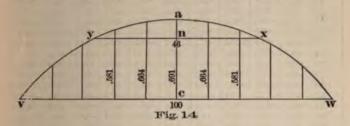
Example.—In a curve of 5730 ft. radius, the middle ordinate of a 100 ft. chord is 218 of a foot; what will be the length of the middle ordinate of a sub-chord of 50 feet? Here,

Sq. of 100 ft.: Sq. of 50 ft.:: Mid. Ord. : Mid. Ord. Sub-Chord approximately.

10000 : 2500 :: 218 ft. : 0545 ft.

Or, they may be found for any radius, thus:

Suppose we need the ordinates for a sub-chord 46 feet long; radius 1810 feet; or chord-deflection angle 3° 10'.



Make a rough pencil sketch, Fig. 14 (which need not be to a scale), of a 100 ft. chord vw, with either all its ordinates for 1810 ft. rad., 5 feet apart (taken from Table, p. 50), or with only alternate ones 10 feet apart, as in the Fig., and set down their lengths. Also draw the given sub-chord yx across as many of the ordinates as its length requires. In this instance of course across 5 of them.

By one of the rules in Art. XV. find the middle ordinate an ('146) of the sub-chord. Subtract it from the middle ordinate ac, or '691. The remainder ('545) will be cn. Now it is self-evident that this '545 taken from '664 and '581 gives the other four sub-ordinates '119 and '036; two of each.

Consequently we have found 5 sub-ordinates for the sub-chord yx. The distances between them must plainly be laid off each way from the middle of the sub-chord, instead of from the ends as usual.

TABLE OF ORDINATES (in Feet).

Ordinates five feet apart. - Chord one hundred feet.

| | ***** | | 1 | | | | | | | |
|---------------------|---------------------|----------|----------|----------|----------|----------|----------|----------|----------|-------|
| Angle of Defi'n. | Middle, 50 feet. | 45 feet. | 40 feet. | 35 feet. | 30 feet. | 25 feet. | 20 feet. | 15 feet. | 10 feet. | 5 fee |
| 0 / | - | 000 | | | | | - | | | |
| 2 | -007 | .007 | .007 | .006 | .006 | .005 | .003 | .003 | -002 | .00 |
| 4 | .014 | .014 | .014 | .013 | .012 | .010 | -008 | -008 | -005 | .00 |
| 6 | .022 | -021 | -021 | .020 | .019 | .016 | -013 | -011 | -008 | .00 |
| 8 | .029 | -029 | .028 | .026 | .024 | -022 | -018 | -015 | .010 | .00 |
| 10 | .036 | .036 | .035 | .033 | -031 | -027 | .023 | -019 | -013 | -00 |
| 12 | .043 | -043 | .041 | -038 | .037 | .033 | .028 | -022 | .015 | .00 |
| 14 | -051 | .050 | .048 | .044 | -043 | -038 | -032 | -026 | .017 | .01 |
| 16 | 4058 | .058 | .056 | .052 | .049 | -044 | .037 | .030 | .020 | .01 |
| 18 | .065 | -065 | .063 | .059 | .055 | .050 | .042 | .033 | .023 | .01 |
| 20 | .073 | .072 | -070 | -066 | -061 | .055 | .047 | -037 | -026 | -01 |
| 22 | -080 | .079 | .076 | .071 | -067 | .060 | -051 | .041 | -029 | -01 |
| 24 | .087 | .086 | .083 | -077 | -074 | .066 | .056 | .045 | .031 | .01 |
| 26 | -095 | .093 | .090 | -084 | -080 | .071 | -060 | .048 | .034 | .01 |
| 28 | .102 | .101 | .098 | -092 | .086 | -077 | -065 | .052 | .036 | .01 |
| 30 | .109 | ·108 | .105 | -099 | .092 | .082 | -070 | .055 | .039 | .02 |
| 32 | .116 | ·115 | .112 | .106 | :098 | -088 | .075 | .058 | .042 | .02 |
| 34 | -123 | .122 | -118 | -111 | .104 | .094 | -079 | -062 | .044 | .02 |
| 36 | -131 | .130 | .126 | .119 | ·110 | .099 | .084 | -066 | .047 | .02 |
| 38 | .138 | .137 | .133 | -126 | -116 | .105 | .089 | .070 | .049 | -02 |
| 40 | .145 | .144 | -140 | 133 | -123 | ·110 | -093 | .074 | .052 | .02 |
| 42 | .153 | .150 | .146 | .138 | .128 | .115 | -098 | .077 | .055 | .02 |
| 44 | .160 | .158 | -153 | -145 | .135 | -121 | ·103 | .081 | -057 | .03 |
| 46 | -167 | .165 | .160 | .152 | .141 | ·126 | -107 | .085 | -060 | .03 |
| 48 | .174 | .172 | -167 | -158 | .147 | .132 | .112 | .088 | .062 | .03 |
| 50 | .182 | -180 | .175 | -166 | .153 | -138 | -117 | .092 | .065 | .03 |
| 52 | .189 | -187 | -181 | -171 | .159 | -143 | .122 | .095 | .068 | .03 |
| 54 | .197 | .194 | .188 | .178 | .165 | .148 | .126 | -099 | .070 | .03 |
| 56 | .204 | .202 | .195 | -185 | -171 | .154 | .131 | .103 | .073 | .03 |
| 58 | .211 | -209 | -202 | .192 | -177 | .159 | -136 | .107 | -075 | .03 |
| 1 00 | -218 | -216 | -209 | .198 | .183 | .164 | .140 | -111 | -078 | .04 |
| 2 | .225 | .223 | -215 | -204 | .189 | .169 | -145 | .114 | 081 | .04 |
| 4 | -233 | -231 | -223 | -211 | .196 | 175 | 150 | 118 | 083 | -04 |
| 6 | -240 | -238 | -230 | -217 | 202 | 180 | 155 | -121 | -086 | -04 |
| 8 | -247 | -245 | -237 | 224 | -208 | .186 | .159 | .125 | .088 | -04 |
| 10 | 255 | 252 | .214 | -231 | .214 | -191 | -163 | .130 | .091 | .04 |
| 12 | -262 | 260 | .252 | -237 | -220 | .196 | -168 | .133 | -094 | -04 |
| 14 | 269 | .267 | -258 | -244 | -226 | 202 | 173 | 136 | -096 | .05 |
| 16 | 276 | 274 | 265 | -251 | -232 | -207 | -177 | .140 | .099 | .05 |
| 18 | 284 | 282 | 273 | 257 | 238 | 213 | -182 | .144 | -101 | .05 |
| 20 | 291 | -288 | -279 | 264 | 244 | -218 | -187 | .148 | .104 | .05 |

Ordinates five feet apart .- Chord one hundred feet.

| | 1 | Distances | of the O | rdinates | from the | end of the | he 100 fee | t Chord. | | |
|---------------------|---------------------|--------------|----------|----------|----------|------------|--------------|--------------|--------------|--------|
| Angle of Defi'n. | Middle, 50 feet. | 45 feet. | 40 feet. | 35 feet. | 30 feet. | 25 feet. | 20 feet. | 15 feet. | 10 feet. | 5 feet |
| 0 1 | 100 | 200 | - | 200 | 200 | 44. | | | - | - |
| 1 22 | -298 | -295 | .285 | .270 | .250 | -224 | .192 | .151 | .107 | +056 |
| 24 | -306 | -303 | 298 | -277 | -256 | -229 | -197 | 155 | -109 | .05 |
| 26 | ·813 | ·310 | -300 | -284 | -263 | .235 | ·201 | .159 | .112 | .059 |
| 28 | -320 | .317 | -307 | •291 | .269 | .240 | .206 | .163 | .114 | .060 |
| 30 | -327 | .324 | 314 | -297 | -275 | .246 | .210 | .167 | .117 | .06 |
| 32 | -334 | -331 | .321 | .304 | .281 | .251 | .215 | .171 | .120 | .06 |
| 34 | -341 | -338 | .328 | -810 | -287 | .257 | -219 | .174 | .122 | .06 |
| 36 | -349 | .345 | -335 | ·317 | -293 | -262 | -224 | .178 | .125 | .06 |
| 38 | *356 | .353 | .342 | -323 | -299 | .268 | -228 | .182 | ·127 | .06 |
| 40 | .364 | ·360 | .349 | .330 | -305 | .273 | .233 | -185 | .130 | .06 |
| 42 | -371 | *367 | .356 | .337 | .312 | .278 | .238 | .189 | .133 | .07 |
| 44 | .378 | .374 | -363 | .343 | -318 | .284 | .242 | .192 | .135 | .07 |
| 46 | .385 | -382 | -370 | -350 | -324 | .289 | -247 | .196 | .138 | -07 |
| 48 | .393 | -389 | -377 | .356 | -330 | .295 | .251 | -200 | -141 | .07 |
| 50 | .400 | -396 | -384 | -364 | -336 | .300 | .256 | .204 | .144 | .07 |
| 52 | -407 | .403 | .391 | -370 | -342 | .305 | -261 | -208 | .147 | .07 |
| 54 | -414 | .410 | -398 | -376 | -348 | -311 | -265 | -211 | .149 | .07 |
| 56 | .422 | -418 | .405 | -383 | .354 | -316 | -270 | -215 | .152 | .08 |
| 58 | -429 | .425 | 412 | -389 | -360 | -322 | -275 | .219 | .154 | .08 |
| 3 | -436 | .432 | .419 | -397 | -366 | -327 | -280 | -222 | .157 | -08 |
| 2 | .443 | -439 | -426 | -402 | -373 | -332 | -284 | -226 | .160 | -08 |
| 4 | -451 | .446 | -433 | -409 | -379 | -838 | -289 | -230 | -162 | .08 |
| 6 | .458 | -454 | .440 | .416 | -385 | -343 | -293 | .234 | -165 | .08 |
| 8 | .465 | .461 | -447 | -425 | -391 | -349 | -298 | -237 | .167 | -08 |
| 10 | .473 | -468 | .454 | -430 | -397 | -355 | -303 | -241 | .170 | -08 |
| 12 | -480 | 475 | -461 | -437 | .403 | -360 | -308 | 245 | -173 | .09 |
| 14 | -487 | .482 | -468 | -443 | .409 | .366 | -312 | -248 | .175 | .09 |
| 16 | 495 | 490 | .475 | -450 | 415 | -371 | -317 | 252 | 178 | -09 |
| 18 | 502 | .497 | .482 | 456 | .421 | -377 | -321 | 256 | -180 | .09 |
| 20 | -502 | .504 | -489 | .463 | .428 | -382 | -326 | 260 | .183 | .09 |
| 22 | -516 | | 496 | .470 | .434 | -387 | | | | |
| 24 | -523 | ·511 ·518 | -503 | .476 | .440 | -393 | ·330 ·334 | ·264 ·267 | ·186 ·188 | -09 |
| 26 | -531 | -526 | -510 | .483 | .446 | -398 | -338 | 207 | 191 | |
| 28 | -538 | -533 | -517 | .489 | 452 | .404 | | 1000 | 191 | .10 |
| | | | | 496 | | | -346 | 275 | | .10 |
| 30 | 545 | -540 | -524 | | 458 | .409 | -350 | .278 | 196 | .10 |
| 32 | .552 | -547 | -531 | .503 | •465 | 415 | -355 | 282 | 199 | .10 |
| 34 | .560 | .554 | .538 | .509 | .471 | •420 | .859 | -285 | -201 | .10 |
| 36 | -567 | -562 | .545 | -516 | .477 | 425 | .364 | -289 | .204 | -10 |
| 88 | .574 | -569 | .552 | .522 | .483 | •431 | -368 | -293 | .206 | -10 |
| 40 | .582 | .576 | .559 | -529 | .489 | .436 | .373 | .297 | -209 | .110 |

Ordinates five feet apart .- Chord one hundred feet.

| ingle of | Middle, | 45 feet. | 40 feet. | 35 feet. | 30 feet. | 25 feet. | 20 feet. | 15 fact | 10 feet. | 5 feet |
|----------|----------|----------|----------|-----------|----------|----------|----------|----------|----------|--------|
| Deff'n. | 50 feet. | 30 1000. | 40 AUCL | 367 ACCC. | SO ICCL. | 20 1000 | 20 1000 | 10 1006. | 10 1000. | 3 1660 |
| 0 / | | 4000 | | 1000 | 100 | 1 | | Town I | 1000 | |
| 2 42 | •589 | .583 | -566 | .536 | -495 | -441 | .378 | -301 | .212 | -111 |
| 44 | -596 | .590 | .573 | .542 | .501 | +447 | .382 | -304 | -214 | -118 |
| 46 | -603 | -598 | .580 | .549 | .507 | .452 | .387 | -308 | -217 | .11 |
| 48 | -611 | .605 | .587 | .555 | •513 | -458 | -391 | .312 | .219 | -110 |
| 50 | -618 | -612 | .594 | -562 | -519 | -464 | -396 | .315 | -222 | -11 |
| 52 | .625 | -619 | -601 | -569 | -526 | -469 | .401 | -319 | .225 | .118 |
| 54 | -632 | -626 | -608 | -575 | •532 | .474 | •405 | .322 | -227 | -119 |
| 56 | .640 | .634 | .615 | .582 | .538 | -480 | .410 | ·326 | .230 | ·12 |
| 0 58 | -647 | -641 | -622 | -588 | .544 | -485 | .414 | .330 | .232 | -12 |
| 3 00 | -654 | -648 | -629 | -595 | .550 | -491 | .419 | -334 | .235 | .12 |
| 2 | -661 | -655 | .636 | -602 | •556 | -496 | -424 | .338 | .238 | .12 |
| 4 | -669 | -662 | .643 | -608 | 562 | -502 | .428 | .341 | .240 | .12 |
| 6 | -676 | -670 | .650 | -615 | -568 | -507 | .433 | .345 | .243 | .12 |
| 8 | -683 | -677 | .657 | -621 | .574 | -512 | -438 | .349 | -246 | .13 |
| 10 | -691 | -684 | .664 | -629 | -581 | -518 | .443 | .353 | .249 | .13 |
| 12 | -698 | -691 | -671 | -635 | .587 | -523 | •448 | .357 | .251 | .13 |
| 14 | .706 | -698 | -678 | .642 | -593 | +529 | .452 | .360 | .254 | .13 |
| 16 | -713 | .705 | +685 | -649 | -599 | .534 | .457 | -364 | .257 | .13 |
| 18 | ·720 | -713 | .692 | -655 | -605 | -540 | .462 | .368 | 259 | .13 |
| 20 | -727 | -720 | -699 | -662 | -611 | .545 | .466 | .371 | .262 | .13 |
| 22 | .734 | -727 | -706 | -668 | -617 | .550 | -471 | .375 | -264 | .13 |
| 24 | .742 | -734 | .713 | -675 | -623 | -556 | .475 | -378 | -267 | -14 |
| 26 | .749 | .742 | -720 | -682 | -629 | -561 | .480 | -382 | -270 | .14 |
| 28 | .756 | .749 | .727 | -688 | -635 | -567 | -485 | -386 | .272 | .14 |
| 30 | .764 | .756 | .734 | -695 | .642 | -573 | .489 | .390 | 275 | .14 |
| 32 | -771 | -763 | .741 | .702 | -648 | -578 | +494 | .394 | .278 | -14 |
| 34 | -779 | .770 | -748 | -708 | .654 | -584 | -498 | .397 | -280 | .14 |
| 36 | .786 | -777 | .755 | -715 | -660 | -589 | .503 | .401 | -283 | -14 |
| 38 | .793 | -785 | .762 | .721 | -666 | .594 | -508 | .405 | .285 | .15 |
| 40 | -800 | -792 | .769 | -728 | -673 | -600 | -512 | .408 | .288 | -15 |
| 42 | -807 | -799 | -776 | .734 | -679 | -605 | -517 | .412 | .291 | .15 |
| 44 | -814 | -806 | .783 | -741 | -685 | -611 | .521 | 415 | -293 | .15 |
| 46 | .822 | -814 | •790 | -748 | -691 | -616 | -526 | -419 | 296 | .15 |
| 48 | .829 | -821 | .797 | .754 | -697 | -621 | -531 | .423 | -298 | .15 |
| 50 | -836 | -828 | .804 | .761 | .703 | -627 | -536 | -427 | -301 | .15 |
| 52 | .843 | .835 | .811 | -768 | -709 | -632 | .541 | .431 | -304 | .16 |
| 54 | -850 | -842 | -818 | -774 | -715 | -638 | .545 | -434 | -306 | -16 |
| 56 | -858 | -850 | -825 | .781 | -721 | -643 | .550 | .438 | .309 | -16 |
| . 58 | -865 | -857 | .832 | -787 | -728 | -648 | -555 | .442 | -311 | .16 |
| 4 | -873 | -864 | -839 | -794 | -734 | -655 | -559 | .445 | -314 | -16 |

Ordinates five feet apart -Chord one hundred feet.

| ngle o Dell'n. 4 5 10 15 20 25 80 85 50 55 10 15 20 25 80 85 80 85 80 85 80 85 80 85 80 85 80 85 80 85 80 85 | -891 -909 -927 -945 -963 -981 -999 1-017 1-036 1-054 1-072 | *882 *900 *918 *936 *954 *972 *990 1.008 1.026 1.044 | ·856 ·874 ·891 ·909 ·926 ·944 ·961 ·979 | ·810 ·827 ·844 ·860 ·877 ·893 ·909 | .749 .764 .780 .795 .810 | -668 -682 -695 -709 -723 | •571 •582 •594 •606 | ·454 ·464 ·473 | 320 327 | •169 |
|--|--|---|--|--|--------------------------------------|--------------------------------------|---|----------------------|------------|-------|
| 4 5 10 15 20 25 30 85 40 45 50 55 10 15 20 25 30 | .909 .927 .945 .963 .981 .999 1.017 1.036 1.054 1.072 | ·900 ·918 ·936 ·954 ·972 ·990 1·008 1·026 | ·874 ·891 ·909 ·926 ·944 ·961 ·979 | ·827 ·844 ·860 ·877 ·898 | ·764 ·780 ·795 ·810 | ·682 ·695 ·709 | ·582 ·594 | ·464 ·473 | -327 | 2000 |
| 10 15 20 25 30 85 40 45 50 55 10 15 20 25 80 | .909 .927 .945 .963 .981 .999 1.017 1.036 1.054 1.072 | ·900 ·918 ·936 ·954 ·972 ·990 1·008 1·026 | ·874 ·891 ·909 ·926 ·944 ·961 ·979 | ·827 ·844 ·860 ·877 ·898 | ·764 ·780 ·795 ·810 | ·682 ·695 ·709 | ·582 ·594 | ·464 ·473 | -327 | 10000 |
| 15 20 25 30 35 40 45 50 55 10 15 20 25 30 | . ·927 ·945 ·963 ·981 ·999 1·017 1·036 1·054 1·072 | ·918 ·936 ·954 ·972 ·990 1·008 1·026 | ·891 ·909 ·926 ·944 ·961 ·979 | ·844 ·860 ·877 ·898 | ·780 ·795 ·810 | ·695 ·709 | .594 | .473 | | -175 |
| 20 25 30 35 40 45 50 55 10 15 20 25 30 | .945 .963 .981 .999 1.017 1.036 1.054 1.072 | •936 •954 •972 •990 1•008 1•026 | ·909 ·926 ·944 ·961 ·979 | ·860 ·877 ·893 | ·795 ·810 | .709 | 100000000000000000000000000000000000000 | 1202 | | |
| 25 30 35 40 45 50 55 10 15 20 25 30 | .963 .981 .999 1.017 1.036 1.054 1.072 | .954 .972 .990 1.008 1.026 | ·926 ·944 ·961 ·979 | ·877 ·898 | -810 | | -606 | | .334 | .176 |
| 30 35 40 45 50 55 10 15 20 25 30 | ·981 ·999 1·017 1·036 1·054 1·072 | .972 .990 1.008 1.026 | ·944 ·961 ·979 | .893 | - | .799 | | .482 | .340 | .179 |
| 85 40 45 50 55 10 15 20 25 80 | .999 1.017 1.036 1.054 1.072 | ·990 1·008 1·026 | ·961 ·979 | | .005 | 120 | -617 | •491 | 347 | .18 |
| 40 45 50 55 10 15 20 25 80 | 1.017 1.036 1.054 1.072 | 1·008 1·026 | -979 | .ana | .070 | .736 | -629 | -501 | 354 | .18 |
| 45 50 55 5 10 15 20 25 80 | 1.036 1.054 1.072 | 1.026 | | 000 | -840 | .750 | -640 | -510 | 360 | -189 |
| 50 55 5 10 15 20 25 80 | 1.054 1.072 | | 0.00 | -926 | -855 | -764 | -652 | -519 | -367 | -198 |
| 5 10 15 20 25 80 | 1.072 | 1.044 | •996 | -943 | -871 | -777 | -664 | -529 | -373 | -196 |
| 5 10 15 20 25 80 | 1.072 | | 1.014 | -959 | -886 | -791 | -676 | -538 | -380 | -199 |
| 5 10 15 20 25 80 | | 1.062 | 1.031 | -976 | -901 | -804 | -687 | -547 | -386 | -20 |
| 5 10 15 20 25 80 | | 1.080 | 1.048 | -993 | -917 | -818 | -699 | -557 | -898 | -207 |
| 10 15 20 25 80 | | 1.098 | 1.065 | 1.009 | -932 | -831 | .711 | -566 | -400 | -210 |
| 15 20 25 80 | 1.127 | 1.116 | 1.083 | 1.026 | -947 | -845 | -722 | -576 | -406 | -214 |
| 20 25 80 | 1.146 | 1.134 | 1.100 | 1.042 | -963 | -859 | .734 | -585 | .413 | -21 |
| 25 80 | | 1.152 | 1.118 | 1.058 | -978 | -872 | .746 | -594 | .419 | -220 |
| 80 | 1.182 | 1.170 | 1.135 | 1.075 | -993 | -886 | .757 | -603 | 426 | -22 |
| | 1.200 | 1.188 | 1.153 | 1.092 | 1.009 | -900 | -769 | -613 | 432 | -228 |
| 99 | | | | | | 100 5000 | 46.000 | -622 | | |
| 40 | | 1.206 | 1.170 | 1.108 | 1.024 | .913 | -781 | | .438 | -23 |
| 40 | | 1.224 | 1.188 | 1.124 | 1.039 | -927 | .792 | -631 | .445 | -23 |
| 45 | 1.255 | 1.242 | 1.205 | 1.141 | 1.055 | .941 | ·804 | -640 | .452 | -238 |
| 50 | | 1.260 | 1.223 | 1.157 | 1.070 | .954 | -816 | -649 | .458 | -241 |
| 6 55 | | 1.278 | 1.240 | 1.174 | 1.085 | -967 | .827 | -658 | .465 | -24 |
| - | 100000000000000000000000000000000000000 | 1.296 | 1.258 | 1.191 | 1.100 | -982 | .839 | .668 | .472 | -248 |
| 5 | 200000 | 1.314 | 1.275 | 1.207 | 1.115 | -995 | ·851 | -677 | -478 | .251 |
| 10 | 1.345 | 1.332 | 1.293 | 1.224 | 1.130 | 1.009 | -862 | -686 | .485 | -25 |
| 15 | | 1.350 | 1.310 | 1.240 | 1.146 | 1.023 | .874 | -696 | -492 | .259 |
| 20 | | 1.368 | 1.328 | 1.256 | 1.161 | 1.036 | -886 | .705 | .498 | -262 |
| 25 | 1.400 | 1.386 | 1.345 | 1.273 | 1.176 | 1.050 | ·897 | .714 | .505 | .26 |
| 30 | 1.419 | 1.404 | 1.362 | 1.290 | 1.192 | 1.064 | -909 | -724 | .511 | -269 |
| 35 | 1.437 | 1.422 | 1.379 | 1.306 | 1.207 | 1.077 | -921 | -733 | -517 | -275 |
| 40 | 1.455 | 1.440 | 1.397 | 1.323 | 1.222 | 1.091 | .932 | -742 | .524 | .276 |
| 45 | 1.478 | 1.458 | 1.415 | 1.339 | 1.238 | 1.105 | -944 | -752 | -531 | -280 |
| 50 | 1.491 | 1.476 | 1.432 | 1.355 | 1.253 | 1.118 | -956 | -761 | -537 | -288 |
| - 55 | April 1997 A Total | 1.494 | 1.450 | 1.372 | 1.268 | 1.132 | -967 | -770 | .544 | -287 |
| 7 | 10000 | 1.512 | 1.467 | | 1.284 | 1.146 | 979 | .779 | 551 | 290 |
| 5 | | 1.530 | 1.484 | | 1.299 | 1.159 | -991 | -788 | -557 | 20 |
| 10 | | 1.548 | 1.502 | 1.422 | 1.314 | | 1.002 | -798 | -564 | 29 |
| 15 | | 1.566 | 1.520 | 1.438 | 1.330 | | 1.014 | -807 | -570 | 301 |
| 20 | | 1.584 | 1.537 | 1.454 | 1.845 | 1.200 | 1.026 | -816 | -576 | 30. |

Ordinates five feet apart .- Chord one hundred feet.

| | - | | Distances | of the C | rdinates | from the | end of t | he 100 fe | et Chord | | |
|-------|-----|------------------|----------------|----------------|-----------|----------|----------|-----------|----------|----------|--------|
| Defl' | | Middle 50 fee | 45 feet. | 40 feet. | 35 feet. | 30 feet. | 25 feet. | 20 feet. | 15 feet. | 10 feet. | 5 feet |
| 7 5 | 1 | 1 010 | 1.602 | 1.555 | 1.471 | 1.960 | 1.214 | 1.037 | -825 | 200 | -308 |
| | 25 | 1.618 | | A 12 2 2 1 | 1.471 | 1.360 | 1.228 | 0.000 | -835 | -583 | |
| | 30 | 1.637 | 1.620 | 1.572 1.589 | 1.504 | 1.375 | 1.241 | 1.060 | -844 | -590 | ·311 |
| - 2 | 35 | 1.655 | 1.638 1.656 | 1.607 | 1.521 | 1.405 | 1-255 | 1.000 | 854 | -596 | -318 |
| | 10 | 1.673 | 1.674 | 1.624 | 1.537 | 1.421 | 1.269 | 1.083 | -863 | -603 | -32 |
| | 15 | 1.692 | 1.692 | 1.641 | 1.553 | 1.436 | 1.282 | 1.095 | -872 | ·610 | -32 |
| | 50 | 1.710 | 1.710 | 1.659 | 1.570 | 1.451 | 1.296 | 1.106 | -881 | 623 | 32 |
| 8 | 55 | 1.728 1.746 | 1.728 | 1.677 | 1.587 | 1.467 | 1.310 | 1.118 | -891 | -629 | -33 |
| ~ | 15 | 1.801 | 1.782 | 1.729 | 1.637 | 1.513 | 1.351 | 1.153 | -918 | -649 | -345 |
| | 30 | 1.855 | 1.836 | 1.782 | 1.687 | 1.559 | 1.392 | 1-188 | .946 | -669 | -35 |
| | 45 | 1.910 | 1.890 | 1.834 | 1.737 | 1.605 | 1.433 | 1.223 | .974 | -689 | -36 |
| 9 | 40 | 1.965 | 1.944 | 1.886 | 1.787 | 1.651 | 1.474 | 1.258 | 1.002 | .708 | -37 |
| | 15 | 2.019 | 1.998 | 1.939 | 1.837 | 1.696 | 1.515 | 1.293 | 1.030 | 728 | 38 |
| | 30 | 2.074 | 2.052 | 1.991 | 1.887 | 1.742 | 1.556 | 1.328 | 1.057 | .748 | -39 |
| | 45 | 2.128 | 2.106 | 2.044 | 1.937 | 1.788 | 1.597 | 1.363 | 1.085 | -767 | -40 |
| iô | 10 | 2-183 | 2.161 | 2.096 | 1.987 | 1.834 | 1.637 | 1.398 | 1.114 | -787 | -41 |
| | 15 | 2.238 | 2.215 | 2.148 | 2.037 | 1.880 | 1.678 | 1.433 | 1.142 | -807 | -42 |
| | 30 | 2.292 | 2.269 | 2.201 | 2.087 | 1.926 | 1.719 | 1.468 | 1.170 | -827 | -43 |
| | 45 | 2.347 | 2.323 | 2.254 | 2.136 | 1.972 | 1.761 | 1.503 | 1.198 | -846 | -44 |
| ıı ı | 40 | 2.401 | 2.377 | 2.306 | 2.186 | 2.018 | 1.802 | 1.538 | 1.226 | -866 | -45 |
| | 15 | 2.456 | 2.432 | 2.359 | 2.236 | 2.064 | 1.843 | 1.574 | 1.254 | -886 | .46 |
| | 30 | 2.511 | 2.486 | 2.411 | 2.286 | 2.110 | 1.884 | 1.609 | 1.282 | -906 | -47 |
| | 45 | 2.566 | 2.540 | 2.464 | 2.336 | 2-156 | 1.926 | 1.644 | 1.310 | -926 | -48 |
| 12 | TO | 2.620 | 2.594 | 2.516 | 2.386 | 2.203 | 1.967 | 1.680 | 1.339 | -946 | .49 |
| | 15 | 2.675 | 2.649 | 2.569 | 2.436 | 2.249 | 2.008 | 1.715 | 1.367 | -966 | -50 |
| | 30 | 2.730 | 2.703 | 2.621 | 2.485 | 2.295 | 2.049 | 1.750 | 1.395 | -985 | -52 |
| | 45 | 2.785 | 2.757 | 2.674 | 2.535 | 2.341 | 2.091 | 1.785 | 1.423 | 1.005 | -53 |
| 13 | 40 | 2.839 | 2.811 | 2.726 | 2.585 | 2.387 | 2.132 | 1.820 | 20000 | 1.025 | .54 |
| | 15 | 2.894 | 2.865 | 2.779 | 2.685 | 2.433 | 2.173 | 1.855 | 1.479 | - | -55 |
| | 30 | 2.949 | 2.920 | 2.832 | 2.685 | 2.479 | 2.214 | 1.891 | 1.507 | 1.065 | -56 |
| | 45 | 3.003 | 2.974 | 2.884 | 2.735 | | 2.256 | 1.926 | | 1.085 | -57 |
| 14 | 2.3 | 3.058 | 3.028 | 2.937 | 2.785 | 2.571 | 2.297 | 1.961 | 10.000 | 1.105 | -58 |
| | 15 | 3.113 | 3.082 | 2.989 | 2.834 | 2.618 | 2.338 | 1.996 | 100000 | 1.124 | .59 |
| | 30 | 3.168 | 3.136 | 3.042 | 2.884 | | 2.379 | 2.031 | | 1.144 | -60 |
| | 45 | 3.222 | 3.191 | 3.094 | 2.934 | 2.710 | 2.421 | 2.067 | 1000000 | 1-164 | -61 |
| 15 | 20 | 3.277 | 3.245 | 3-147 | 2.984 | | 2.462 | 2.102 | 13 5 3 3 | 1.184 | -62 |
| | 15 | 3.332 | 3.299 | 8-200 | | | 2.503 | 2.137 | | 1.204 | -63 |
| | 30 | 3.387 | 3.354 | 3.252 | 3.084 | 2.848 | 2.544 | 2.172 | 12 032 | 1.224 | -64 |
| | 45 | 3.442 | 3.408 | 3.305 | 100000000 | | 2.586 | 2.208 | 10-20- | 1.244 | -65 |
| 16 | 20 | 3.496 | 3.462 | 3.358 | 3.184 | 2.941 | 2.627 | 2.243 | 1.789 | | -66 |
| | | 200 | 3 102 | 000 | 3 101 | TE OXI | 2021 | 2 220 | 1 100 | 201 | 00 |

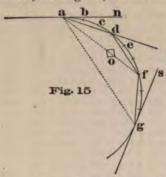
Ordinates five feet apart .- Chord one hundred feet.

| ngle of Defi'n. | Middle, 50 feet. | 45 feet | 40 feet. | 35 feet. | 30 feet. | 25 feet. | 20 feet. | 15 feet. | 10 feet. | 5 feet. |
|--------------------|---------------------|---------|----------|----------|----------|----------|----------|----------|----------|---------|
| 01 | Maria | | | | | | | | | - |
| | 3.606 | 3.571 | 3.463 | 3.284 | 3.033 | 2.710 | 2.314 | 1-0-0 | 1.304 | -688 |
| 17 | 3.716 | 3.680 | 3.569 | 3.384 | 3.125 | 2.792 | 2.384 | 1.902 | | -709 |
| 0 00 | 3.826 | 3.788 | 3.674 | 3.484 | 3-218 | 2.875 | 2.455 | 1.958 | 1.384 | .730 |
| 18 | 3.935 | 3.897 | 3.779 | 3.584 | 3.310 | 2.958 | 2.525 | 2.014 | 1.424 | .75 |
| . 30 | 4.045 | 4.006 | 3.885 | 3.684 | 3.403 | 3.040 | 2.596 | 2.071 | 1.464 | -77 |
| 19 | 4.155 | 4.115 | 3.990 | 3.784 | 3.495 | 3.123 | 2.666 | 2.127 | 1.504 | .798 |
| , 30 | 4.265 | 4.223 | 4.096 | 3.884 | 3.588 | 3.205 | 2.737 | 2.184 | | .81 |
| 20 | 4.375 | 4.332 | 4.201 | 3.984 | 3.680 | 3.288 | 2.808 | 2.240 | | .83 |
| 21 | 4.595 | 4.549 | 4.412 | 4.184 | 3.864 | 3.454 | 2.950 | 2.353 | 1.663 | .87 |
| 22 | 4.815 | 4.768 | 4.624 | 4.386 | 4.050 | 3.620 | 3.093 | 2.467 | 1.744 | -92 |
| 23 | 5.035 | 4.986 | 4.886 | 4.587 | 4.237 | 3.786 | 3.236 | 2.581 | 1.824 | .96 |
| 24 | 5.255 | 5.204 | 5.048 | 4.789 | 4.423 | 3.952 | 3.379 | 2.695 | 1.905 | 1.00 |
| 25 | 5.476 | 5.422 | 5.260 | 4.989 | 4.609 | 4.119 | 3.522 | 2.809 | 1.986 | 1.05 |
| 26 | 5.697 | 5.642 | 5.478 | 5.192 | 4.798 | 4.286 | 3.665 | 2.924 | 2.068 | |
| 27 | 5.918 | 5.860 | 5.685 | 5.393 | 4.984 | 4.454 | 3.808 | 3.039 | 2.150 | 1.13 |
| 28 | 6.139 | 6.079 | 5.898 | 5.595 | 5.171 | 4.622 | 3.952 | 3.154 | 2.232 | 1.18 |
| 29 | 6.361 | 6.298 | 6.110 | 5.796 | 5.357 | 4.790 | 4.095 | 3.269 | 2.314 | 1.22 |
| 30 | 6.582 | 6.517 | 6.323 | 5.999 | 5.544 | 4.958 | 4.239 | 3.385 | 2.396 | 1.26 |
| 31 | 6.804 | 6-737 | 6.537 | 6.202 | 5.733 | 5.127 | 4.384 | 3.502 | 2.481 | 1.31 |
| 32 | 7-027 | 6.957 | 6.751 | 6.406 | 5.922 | 5.297 | 4.530 | 3.619 | 2.565 | 1.35 |
| 33 | 7.252 | 7.178 | 6.965 | 6.609 | 6.111 | 5.467 | 4.676 | 3.737 | 2.649 | 1.40 |
| 34 | 7.472 | 7.398 | 7.179 | 6.813 | 6.300 | 5.687 | 4.822 | 3.854 | 2.733 | 1.44 |
| 35 | 7.694 | 7.619 | 7.393 | 7.017 | 6.489 | 5.807 | 4.968 | 3.972 | 2.817 | 1.49 |
| 36 | 7.918 | 7.841 | 7.609 | 7.222 | 6.679 | 5.978 | 5.115 | 4.090 | 2.901 | 1 53 |
| 37 | 8-143 | 8.063 | 7.825 | 7.427 | 6.870 | 6.149 | 5.262 | 4.209 | 2.985 | 1.58 |
| 38 | 8-367 | 8-286 | 8.041 | 7.633 | 7.060 | 6.320 | 5.410 | 4.327 | | 1.62 |
| 36 | 8.592 | 8.508 | 8.257 | 7.838 | 7-251 | 6.491 | 5-557 | 4.446 | | |
| 40 | 8.816 | 8.731 | 8-474 | 8.044 | 7.442 | 6.663 | 5.705 | 4.565 | 3.238 | |

ARTICLE XVIII.

On Long Chords.

It is sometimes convenient, in preliminary locations, to lay off curves by chords longer than 100 feet. For instance, in Fig. 15, instead of running from a by chords



a b, b c, c d, etc., of but 100 feet, points d, f, g, etc., may be obtained with less trouble by using three times the tangential or deflection angles of the table (as the case may be), and employing chords a d, d f, f g, etc., nearly three times as long as the chords a b, b c, etc.; or if a d, d f, f g be either 2 or 4 stations apart, then 2 or 4 times the

tangential and deflection angles would be used; and chords nearly 2 or 4 times 100 feet in length.

The next table contains the correct length of chord required to subtend from 1 to 6 stations,

To find the length of a Long Chord to subtend any given number of 100 ft. chords.

Rule.—Multiply the tangential angle for 100 ft. chords by the given number of 100 ft. chords. The product will be half the central angle subtended by the long chord. Find the nat sine of this angle. Multiply this sine by the radius of the curve. The product will be half the long chord. Multiply it by 2.

Or, as a formula,

Long Chord=sine of (tangl. angle \times No. of 100 ft. chords) \times radius \times 2.

To find the Middle Ordinate of any Long Chord, if such should be desired.

Rule.—Multiply the tangential angle for 100 ft, chords by the number of 100 ft, chords subtended by the long chord. Find the nat. versed sine of the product. Multiply this versed sine by the radius of the curve.

Remark I .- Long chords may at times be useful for

passing an obstacle.

Thus, suppose we are running the curve ag, Fig. 15, by tangential angles and chords ad, df, fg, of 100 feet; the transit being at a. An obstacle o prevents taking a sight on f; but the curve may still be continued from a by using a long chord ag, subtending the three 100 ft. chords. The angle nag or sg a will here equal the sum of the three tangential angles nad, daf, fag.

It is plain that from a we may, if necessary, continue the curve beyond g by tangential angles and 100 ft. chords

as before meeting with the obstacle.

This Method, and those in Arts. I. and XXXVII., will cover nearly all cases in practice for the passing of obstacles.

Remark 2.—With the method of curving by long chords alone, the instrument should be moved to each successive point after it is determined, in order to fix the next one, instead of attempting to obtain more than one point from one position of the instrument; because when the chords are longer than one chain they cannot be measured in the right direction by eye, but must be guided by the instrument.

Remark 3.—It must be borne in mind that, in any given curve, only the tangential and deflection angles increase in the same proportion as the number of 100 feet stations subtended by the long chord. Therefore, these long chords cannot be used for laying out curves by eye, as their tangential and deflection distances are not here given.

When it is required to use long chords for turning a curve by Art. 3, they should be composed of a number of whole chains, being made say, 200, 300, or 400, etc., feet in length, because the deflection distances of curves of given radius are exactly, and the tangential distances approximately as the squares of the number of chains in the length of the long chord. For instance, to lay off a 5° curve by chords of 200, 300, or 400 feet in length, the tangential and deflection distances of the table must be multiplied by 4, 9, or 16, as the case may be. In this case the tangential and deflection angles are unknown.

TABLE OF LONG CHORDS.

| Radius in feet. | Angle of Deflection. | Length of Chord in feet required to subtend | | | | | | | |
|-----------------|-------------------------|---|--|-------|-------|-------|---------------|--|--|
| PHO0.0 | 30 | - | A CONTRACTOR OF THE PARTY OF TH | - | | | Maria Control | | |
| 5729.6 | 10 | 100 | 200.0 | 300.0 | 399.9 | 499.8 | 599.7 | | |
| 4583.8 | 4 | 100 | 200.0 | 300.0 | 399.9 | 499.8 | 599.6 | | |
| 3819.8 | 2 | 100 | 200.0 | 299.9 | 399.8 | 499.7 | 599.4 | | |
| 3274.2 | 20 4 | 100 | 200.0 | 299-9 | 399.8 | 499.5 | 599-2 | | |
| 2864.9 | 20 | 100 | 200.0 | 299.9 | 399.7 | 499.4 | 598.9 | | |
| 2546.6 | 4 | 100 | 200.0 | 299.9 | 399.6 | 499.2 | 598.6 | | |
| 2292.0 | 2.3 | 100 | 200.0 | 299.8 | 399.5 | 499.0 | 598.3 | | |
| 2083.7 | | 100 | 200.0 | 299.8 | 399.4 | 498.8 | 598.0 | | |
| 1910.1 | 30 | 100 | 199.9 | 299.7 | 399.3 | 498.6 | 597.6 | | |
| 1763.2 | 4 | 100 | 199.9 | 299.7 | 399.2 | 498.4 | 597.2 | | |
| 1637.3 | 2 2 | 100 | 199.9 | 299.6 | 399.1 | 498.1 | 596.7 | | |
| 1528.2 | 4 | 100 | 199.9 | 299.6 | 399.0 | 497.9 | 596.2 | | |
| 1432.7 | 40 | 100 | 199.9 | 299.5 | 398.8 | 497.6 | 595.7 | | |
| 1348.5 | 1 | 100 | 199.9 | 299.5 | 398.6 | 497.3 | 595.2 | | |
| 1273.6 | 5 3 | 100 | 199.8 | 299.4 | 398.5 | 496.9 | 594.6 | | |
| 1206.6 | 34 | 100 | 199.8 | 299.3 | 398.3 | 496.6 | 594.0 | | |
| 1146.3 | 50 4 | 100 | 199.8 | 299.2 | 398.1 | 496.2 | 593.4 | | |
| 1091.7 | 1 | 100 | 199.8 | 299.1 | 397.8 | 495.8 | 592.7 | | |
| 1042.1 | 1/2 | 100 | 199.8 | 299.0 | 397.7 | 495.4 | 592.0 | | |
| 996.9 | 34 | 100 | 199.7 | 298.9 | 397.5 | 495.0 | 591.2 | | |
| 955.4 | 60 | 100 | 199.7 | 298.9 | 397.3 | 494.5 | 590.4 | | |
| 917.2 | 1 | 100 | 199.7 | 298.8 | 397.0 | 494.1 | 589.6 | | |
| 881.9 | + | 100 | 199.7 | 298.7 | 396.8 | 493.6 | 588.8 | | |
| 849.3 | 3 4 | 100 | 199.6 | 298.6 | 396.5 | 493.1 | 587.9 | | |
| 819.0 | 70 * | 100 | 199.6 | 298.5 | 396.3 | 492.6 | 587.0 | | |
| 790.8 | 1 | 100 | 199.6 | 298.4 | 396.0 | 492.0 | 586.1 | | |
| 764.5 | 1 | 100 | 199.6 | 298.3 | 395.7 | 491.5 | 585.1 | | |
| 739.9 | 34 | 100 | 199.6 | 298.1 | 395.4 | 490.9 | 584.1 | | |
| 716.8 | 80 4 | 100 | 199.5 | 298.0 | 395'1 | 490.3 | 583-1 | | |
| 695.1 | 1 | 100 | 199.5 | 297.9 | 394.8 | 489.7 | 582.0 | | |
| 674.7 | | 100 | 199.5 | 297.8 | 394.5 | 489.1 | 580.9 | | |
| 655.4 | \$ 34 | 100 | 199.4 | 297.7 | 394.2 | 488.4 | 579.8 | | |
| 637.3 | 90 * | 100 | 199.4 | 297.5 | 393.9 | 487.7 | 578.6 | | |
| 620.1 | 1 | 100 | 199.4 | 297.4 | 393.5 | 487.1 | 577.4 | | |
| 603.8 | 1 2 | 100 | 199.3 | 297.3 | 393.2 | 486.4 | 576-2 | | |
| 588.4 | 3 | 100 | 199.3 | 297.1 | 392.8 | 485 6 | 575.0 | | |
| 573.7 | 100 | 100 | 199.2 | 297.0 | 392.4 | 484.9 | 578.7 | | |

For radii less than 573.7 feet, it is never required to use longer chords than 100 feet.

Remark.—Intermediate ones may be found by simple proportion.

CHAPTER III.

COMPOUND AND REVERSE CURVES, ETC.

ARTICLE XIX.

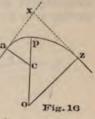
WE have hitherto spoken only of *simple* curves; that is, of such as are parts of only one circle; and hence have but one radius, and *equal apex distances*.

Compound Curves Defined.

When a curve, as a p z, Fig. 16, has apex distances, x a,

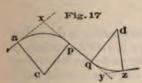
xz, of different lengths, it must also have at least two different lengths pc, po, of radius; and if the curve also runs in one general direction, like apz, (instead of in two directions, like arw, Fig. 18), it is called a compound curve.

The point p, at which the change of radius occurs, is called the Point of Compound Curvature; and the stake at that point in a survey, is marked P C C.



Reverse Curves Defined.

When one of two adjacent tangents (xy and yz, Fig.



17; or xy and yw, Fig. 18) deflects to the right, and the other to the left, their two curves ap and qz, Fig. 17, must also deflect in different directions, as seen in the two Figs. When these curves, as ar and rw, Fig. 18, touch each

other, as at r, Fig. 18, the two together constitute a true Reverse Curve. They are often called reverse curves, even when, as in Fig. 17, they are separated by a short tangent pq.

Remark I.—Reverse curves should never be run without such an intermediate tangent, if it is possible to avoid

doing so; because the omission prevents the proper elevation of the outer rail of the curves, and thus enforces a reduction of speed in travelling around them.

Remark 2.—The two branches or arcs of a reverse curve may have either equal or unequal radii; or each branch

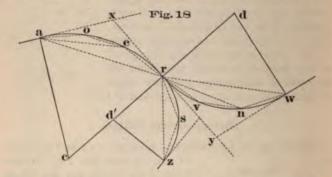
may be in itself a compound curve.

Remark 3.—The introduction of the tangent pq, Fig. 17, evidently transforms a true reverse curve into two entirely detached simple ones, ap, qz, each subject to all the rules for such.

ARTICLE XX.

The laying-out of Compound and Reverse Curves.

This is a very simple operation, requiring no further knowledge of principles than is taught in Art. I. Thus, starting at a, we run the first branch a r by means of tan-



gential angles x a o, o a e, e a r, corresponding to the radius a c or r c; and with 100 ft. chords a o, o e, e r, precisely as in Art. I. Arriving at the end r, we move the instrument to that point, and lay off either a single tangential angle e r x, or the triple one a r x, etc., thus bringing the telescope to sight along x r. Revolving the telescope, it will sight along the tangent r y, or x r continued. Now it is plain that if, starting from this tangent r y, we continue to lay off the same tangential angles as before, we shall thereby extend the curve a r of radius r c. But if we lay off new tangential angles y r s, s r z, etc., corresponding to the radius

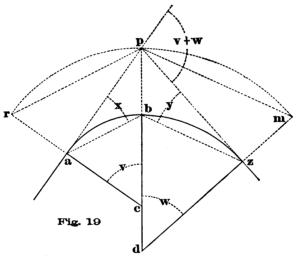
rd' or zd', we shall complete the compound curve arz. Or if, from the *opposite side* of the same tangent ry, we lay off tangential angles yrv, vrn, nrw, etc., corresponding to the radius rd or wd, we thereby complete the reverse curve arw.

ARTICLE XXI.

Having given the two unequal apex distances a p, p z, Figs. 19 and 20; and the total deflection angle, or total central angle, v + w, Required to find two radii a c and z d, for a compound curve a b z, to unite a and z tangentially.*

RULE.

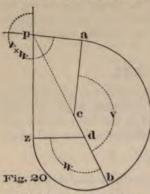
1st. Find the sum, and also the difference, of the apex distances.



Remark.—If, as in Fig. 21, the tangents are parallel, there will be no apex distances. For such cases see Art. XXII.

^{*} The above rule enables us to join any two points. It always gives a curve in which the line $c\,b$, dividing the two branches, will, when extended, strike the apex p; which will rarely happen when the radii are determined upon beforehand, as in Art. XXIII.

2d. Divide the total deflection angle, v + w, by 2. The



quotient will be the sum of the two tangent angles x and y, Fig. 19. Call this sum s; and call their unknown difference d.

Remark.—The same principle applies to Fig. 20, but cannot be conveniently illustrated in that Fig. Many of the dotted lines in Fig. 19 are merely to aid in our subsequent demonstration.

3d. Then say, as the

Sum of the apex dists. Diff. of the apex dists. Sine of s of d.

4th. From the table of sines take the angle d corre-

sponding to the sine last found.

5th. Add together s and d. Divide their sum by 2. The quotient will be x, the greater of the two angles; and s - x gives y, the lesser angle.

6th. Find the angle v = twice x; and the angle w =

twice y.

7th. Radius dz is $=\frac{apex\ distance\ p\ z}{tangent\ of\ w}$;

and Radius e a is $= \frac{apex \ distance \ p \ a}{tangent \ of \ v}$.

Remark.—When this rule is used the *larger* angle, v, always corresponds to the *shorter* apex distance, a p.

DEMONSTRATION.

The foregoing process is based upon the principle that, as the

Sum of the tangents of any two angles : Diff. between said two tangents : Sine of the sum of the diff. of the two angles two angles.

Referring to Fig. 19, we have

 $ra = pa \times \text{tang. of } rpa$. Also rpa = x. ra = a $pa \times \text{tang. of } x$.

Also $p\vec{b} = ra$. $pb = pa \times tang$. of x.

Also $mz = pz \times \text{tang. of } mpz$. And mpz = y. ... $mz = pz \times \text{tang. of } y$.

Also pb = mz. ... $pb = pz \times tang$. of y.

 $pa \times tang.$ of $x = pz \times tang.$ of y; or, as pa : pz:: tang. of y: tang. of x.

pa, then, represents tang. of y; and pz represents tang. of x; and we have, as in 3d,

pa+pz:pa-pz, or pz-pa: Sine of (x+y): Sine of (x-y).

ARTICLE XXII.

To connect tangentially by a compound curve, ab z, Fig. 21, two points a and z, not directly opposite each other, on parallel tangents ka and zn.

Required to find the radii cb and db.

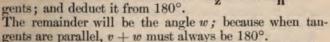
We must first find the central angles, v and w, of the two branches of the curve, thus:

Rule.—Divide the perpendicular distance kz between

Fig. 21

the tangents, by the distance kawhich the ends of the curve want of being opposite each other. The quotient will be the tangent of kaz. Now ka is perpendicular to dz, and by drawing db perpendicular to azwe make zdb, or v, equal to kaz* Therefore $kz \div ka =$ tangent of v.

Find v in the table of tan-



From the table take the versed sines of v, and of w. Then

^{*}The points a and z may be joined by other compound curves, in which db is not perpendicular to az, but by making it perpendicular we obtain a satisfactory curve, and a simple method of finding the radii.

Radius $cb = half kz \div versed sine of w;$ and Radius $db = half kz \div versed sine of v;$

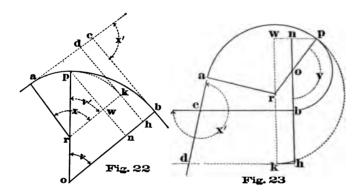
for when the tangents ka and zn are parallel, a line an joining them at right angles is $= (db \times ver. sine of v) + (ac \times ver. sine of w)$.

And when db is made perpendicular to az, then $(ac \times ver. sine of w) = (db \times ver. sine of v) = half <math>an$.

ARTICLE XXIII.

Having the total deflection angle, x', Figs. 22 and 23, between two tangents, a c and c b, which are to be united by a compound curve a p b, starting from a, it is

Required, to find how far a c, from the apex, c, to begin the curve. See footnote to Art. XXVI.



We must first decide what radii, p r and p o; and what lengths, in chords, the two branches, a p and p b, of the curve shall have.

Rule.—Find the central angle, v, subtended by the second branch, p b, of the curve,— its chord-deflection angle \times its number of chords.

Find, in the table, p. 170, the versed sine of this angle. v.

Find the difference, ro, in length between the radii po and pr.

Fig. 24

Find $bh = ro \times \text{versed sine of } v.*$ Find in the table, p. 124, the sine of x'.

Find $d c = b h \div \text{sine just found.}$

Find in the table, p. 124, the tangent of half the central angle x.

Find $ad = \text{radius } ar \times \text{tangent just found.}$

Find a c, thus:

Case I.—When x is less than 180° , ac = ad + dc.

Case 2.—When x exceeds 180°, and the shorter radius is run first, ac = ad + dc.

Case 3.—When x exceeds 180°, and the longer radius is run first, ac = ad - dc, or

Case 4. ac = dc - ad.

For the starting point a, from c measure a c backward, in Cases 1 and 4; or forward in Cases 2 and 3.

ARTICLE XXIV.

Having the total deflection angles x b i and w c i, Fig. 24, and the distance be, it is,

Required to find the greatest radius, g i or h i, that can be employed in a reverse curve, foinm, for uniting a b to cd; and to locate the point of curve, f; or point of tangent, m.

Rule.—From the table, p. 124, take the tangent of b q i, = half of x b i; and the tangent of ihc = half of wci. Add these two tangents together, and divide bc by their sum. quotient is the greatest common radius, gi or hi.

Find the apex distance bi or a

 $bf = \text{radius } q i \times \text{tangent of } b q i.$ Find the apex distance ci or

 $c m = \text{radius } h i \times \text{tangent of } i h c; \text{ or } = b c - b i.$

Example.—Let x b i be 108° 20'; w c i 50° 45'; and the distance b c 950 feet. What is the length of radius hi or gi, of the easiest reverse curve for uniting ab to

E

^{*} Because if we imagine the first branch, ap, of the curve to be extended forward to k, so as to subtend the angle x = x', and from p draw pwn at right angles to ob, then wk (=nh) is $= rp \times ver$, sine of v'(=v); $nb = op \times ver$. sine of v; and bh is = nb - nh, or nh - nb= the difference ro of the radii × ver. sine of v.

cd; how far, bf, back from b must the curve begin; and how far, cm, forward from c will it end?

Here we have,

half of $x b i (108^{\circ} 20') = 54^{\circ} 10'$; its tangent 1·3848; and half of $w c i (50^{\circ} 45') = 25^{\circ} 22\frac{1}{2}'$; its tangent ·4743. The sum of these tangents = 1·3848 + ·4743 = 1·8591.

Radius q i or hi = bc (950 ft.) ÷ 1.8591 = 511 ft.

Apex distance bi or bf = Rad. gi or hi (511 ft.) \times

tang. of half x b i (1.3848) = 707.63 ft.

Apex distance ci or cm = Rad. gi or hi (511 ft.) \times tang. of half wci (4743) = 242·37 ft.; or = bc - bi = 242·37 ft.

ARTICLE XXV.

To alter the last part of a Curve so that it will properly join a New Tangent.

Remark.—This problem covers most of the cases that occur in practice; but at times certain restrictions present themselves which require other methods, some of which will be found further on.

Having from a, Figs. 25, 26, 27, and 28, run a curve a b, ending in a tangent b e, we wish to alter the radius of the last part of it, so that it shall connect tangentially with a new tangent g f, either parallel to the old one b e, or not.

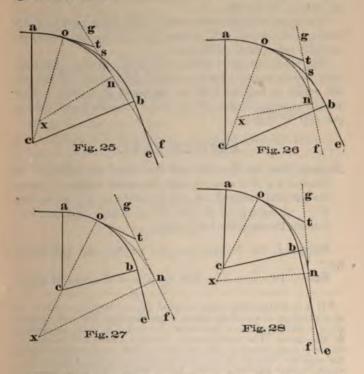
Rule.—From any point o of the curve (which point must be back from s, when, as in Figs. 25 and 26, the new tangent gf cuts the curve) run a short tangent ot to meet the new one gf. Measure both ot and the outer meeting angle ot g. This angle will be equal to the central angle, oxn, of the new part, on, of the curve. Hence

New radius $ox = \frac{ot}{\tan g}, \text{ of } \frac{1}{2} ox n = \frac{ot}{\tan g}, \text{ of } \frac{1}{2} ot g$

Remark I.—If we do the same thing at a, we shall get a radius which will give a *uniform* curve from a to the new tangent gf; and this will often be better than the compound curve otherwise obtained.

Remark 2.—When, as in Figs. 25 and 26, the new tangent gf cuts the curve, as at s (or if it should cut an extension of the curve forward from b), then any new radius ox will be shorter than the old one bc; lengthening, however, the

farther we go back from b; but when, as in Figs. 27 and 28, the new tangent does *not* cut the curve (or an extension of it forward from b), any new radius ox will be *longer* than the old one bc; shortening, however, the farther we go back from b.



Remark 3.—It does not always follow that the end of the new part of the curve of greater radius than the old part will always extend beyond b, as in Fig. 27; nor that one of shorter radius will fall behind b.

Remark 4.—In curves not exceeding 180° long, if the error is small, it may be humored in by dividing it equally among the chords by measure, without retracing the curve with an instrument. This method may be employed with perfect security so long as the error does not exceed 1 foot

to every chord of 100 feet; and it will never be so great if moderate care be taken.

Thus, if the curve be 20 chords long, and the error 20 feet, the last stake may be moved 20 feet, the next 19, the next 18, etc., as nearly at right angles to the curve as can be judged by the eye.

The same ordinates that would have been used had the curve been correct, will answer for the one so adjusted,

without perceptible difference.

The resulting curve will not be truly circular, although very closely so; still, for the sake of uniformity throughout the route, it had as well be corrected at leisure, before actual grading begins, if the error exceeds 2 or 3 inches per 100 ft. chord.

ARTICLE XXVI.

Having from a, Figs. 29 and 30, run a curve a b to the tangent b s, it is desired, with the same radius, to strike the parallel tangent og, either inside of bs, as in the Figs., or outside of it; the perpendicular distance, bc, between the tangents being given.

Required, the distance, an, for starting the new curve

Rule.—In either Fig. find the sine of the central angle

In the simple curve a e b, Fig. 30, the true central angle a x b is that on the right of the two radii a x and b x; while the angle a x b on the left of those radii is the *substitute* angle; always equal to what the

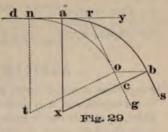
central angle wants of being 360°.

The same care is necessary with regard to the total deflection angle, (shown by the dotted arc around r, Fig. 30) where two tangents of a curve of more than 180° meet. Whether the curve is greater or less than 180°, this angle, in a simple curve, is always equal to the central angle; or, in a compound curve, to the sum of its two or more central angles.

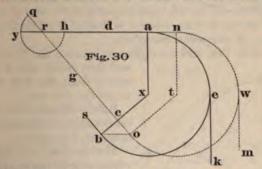
^{*}It must be carefully borne in mind that in Fig. 30, as well as in all that follow in which the curve is greater than 180°, the central angle is the larger one at the centre, and is the one there subtended by the curve. The smaller one at the same centre, and denoted by the very same letters, is what we have called the substitute angle. See page 30. In some of the problems this is substituted for the true central angle; but when so, the fact is stated. No error, however, would arise from taking the sine, cosine, tangent, etc., of one for that of the other, inasmuch as they are the same for both angles.

axb, subtended by the curve. Divide the given distance bc by this sine. The quotient will be the distance bc = an; to be measured backward from a to n, when, as in

Fig. 29, the new tangent og is back towards the beginning of the survey, from the old tangent bs; and to be measured forward from a to n, when, as in Fig. 30, the new tangent og is forward towards the end of the survey, from the old tangent bs.



Remark.—If the central angle $a \times b$ is just 90° (as it would be with the tangents e k and w m in Fig. 30); or just 270°, the sine is 1; and the dist a n is $= e w \div 1 = e w$. If the central angle



be 180°, the sine is 0; and the problem is impossible. Lathis case a change of tangents would require a change in the length of the radius.

DEMONSTRATION.

Since the two curves ab and no, in either one of the figs., starting from the same tangent nr, are equal, bo must be equal to its parallel an. And as bo is made parallel to the tangent, da, boc is, in Fig. 29, evidently equal to total deflection angle yro = axb; and in Fig. 30, to the supplement, yrq, of total deflection angle drq.

Now an angle and its supplement (see p. 121) have the same sine.

As bx is perpendicular to og, bc is $= bo \times sine$ of boc or of axb.

In other words,

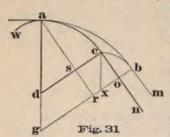
$$a n (= b o)$$
 is $= \frac{b c}{\text{sine of } b o c} = \frac{b c}{\text{sine of central angle.}}$

ARTICLE XXVII.

Having from a run a curve, a c, Figs. 31 and 32, ending in a tangent, c n, it is desired to start again at the same point, a, and to run a curve, a b, either of longer radius, as in the figs., or of shorter radius, to unite with a tangent, as b m, parallel to c n; and either outside of c n, as in the figs., or inside of it.

Required, the new radius. See footnote to Art. XXVI. Remark.—This rule applies equally to the case of a compound curve, as wac, where it is desired to retain the same point, a, of compound curvature.

Here we first find the difference between the two radii;



and then either add it to, or take it from, the first radius to get the new one.

Rule.—Measure the shortest distance, ob, between the tangents, bm and cn.

Divide this ob by the versed sine of the central angle, adc, subtended by the curve. The quotient is the difference, dq, between the radii.

Then if the new tangent, b m, lies outside the old one, c n, as in the figs., add dg to the old radius, a d, for the new one, a g.

If the new tangent lies inside the old one, subtract dg

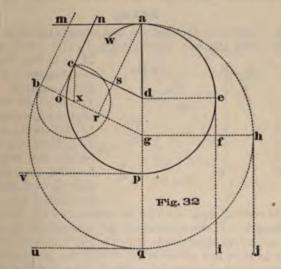
from the old radius, for the new one.

Remark.—If the central angle is just 90°, as a d e, Fig. 32, or just 270°, the difference d g between the radii will be equal to the distance f h between tangents f i and h j; because the versed sine of 90°, or of 270°, is 1.

If the total angle is just 180° , as agq, Fig. 32, the difference dg between the radii will be equal to half the distance pq between the tangents pv and qu; because the versed sine of 180° is 2.

DEMONSTRATION.

From a draw the dotted line ar, parallel to the two tangents, bm and cn, and therefore perpendicular to dc



and gb. Then $sc = \text{radius } ad \times \text{versed sine of central angle}$; and $rb = \text{radius } ag \times \text{versed sine of central angle}$.

The distance b o between the tangents is $= rb - sc = (ag \times \text{ver. sine of central angle}) - (ad \times \text{ver. sine of central angle}) = (ag - ad) \times \text{ver. sine of central angle},$ as shown by the dotted line, xc, and dotted are, cb.

Hence difference dg of radii, or ag - ad, is

$$=\frac{0.0}{\text{ver. sine of central angle}}$$

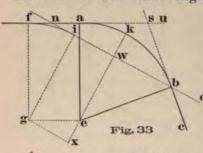
ARTICLE XXVIII.

Having from a, Figs. 33 and 34, run a curve, a b, ending tangentially in b c, we wish to change the starting-point from a to f, so that with the same radius, ea, we shall strike, as at i, a new tangent, b d, passing through b, and deflecting either inward or outward from b c.

Required the distance a f. See footnote to Art. XXVI.

RULE.

1st. Place the instrument at b, and measure the angle dbc. **2d.** Find the new central angle, fgi (= und), thus:



If, as in Fig. 33, the new tangent, bd, deflects outward, then fgi is = old central angle aeb (subtended by the curve) minus dbc. Or if, as in Fig. 34, the new tangent, bd, deflects inward, then fgi (of the entire dotted arc fi) is

= old central angle, a e b (of the entire arc a b), plus d b c.

Remark.—If the new tangent, b d, is parallel to the original one, as (in other words, if f g i is 180°), then the radius must be shortened so as to be = half the perpendicular distance between a s and the new tangent, and the curve may start from any convenient point, as a, f, etc., etc., on the tangent n u.

3d. Find $ex = kw = radius ea \times ver$. sine of dbc.

4th. Find $qe (= af) = ex \div \text{sine of } fqi$.

5th. If, as in Fig. 33, the new central angle is less than 180°, measure af, thus found, backward from a. If, as in Fig. 34, the new central angle exceeds 180°, measure af forward from a.

Example.—In Fig. 34 the new tangent, b d, deflects

inward from the first one, bc. Therefore,

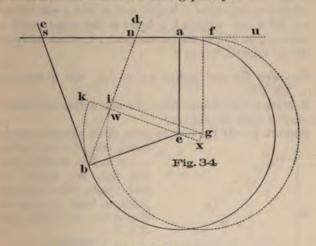
1st. Measure $dbc = \text{say } 40^{\circ}$.

2d. Find fgi or und = aeb (say 250°) +dbc (say 40°) = 290°.

3d. Find $ex = (kw) = \text{radius } ea \text{ (say 100 ft.)} \times \text{ver.}$

sine (.234) of dbc = 23.4 ft.

4th. Find $af = ex(23.4) \div \text{sine}(.940)$ of fgi = 24.9 ft. 5th. Since fgi exceeds 180° , measure af(24.9) ft.) forward from a for the new starting-point f.



DEMONSTRATION.

Draw the line k w e x, Figs. 33 and 34, perpendicular to new tangent b d, and passing through the old center e. Since k e and b e are respectively perpendicular to both the new and the old tangents, b e k is = d b c. If the curve were to be pushed back from k, along the line k x, it evidently must, in order to become tangential to b d, move through the distance $e x (= k w) = \text{radius} \times \text{ver. sine of } k e b \text{ or of } d b c$. But the curve must be tangential, not only to b d, but also to a u; and the center of the curve must, therefore (after moving from e to x), move along the line x g, perpendicular to e x, and parallel to b d, until its perpendicular distance f g from a s is = radius e a.

Now, to find the distance eg (= af), through which

to move the curve at once from e or a, we have,

Since x g and e g are respectively parallel to b d and n u, e g x is = u n d = f g i. In the right-angled triangle e x g, e x is evidently $= e g \times \sin of e g x$ (or of f g i). In other words, e g (= a f) is $= e x \div \sin of f g i$.

ARTICLE XXIX.

Having from a, Figs. 35 and 36, run a curve, a b, to b, where it is tangential to b c, we wish to find a new radius, a g, for a new curve, a i, to begin at the same point, a, and end, as at i, in the new tangent, i d, which intersects the old tangent, b c, at b.

Required the new radius a g or i g. See footnote to Art. XXVI.

Remark I.—In this problem, the new radius will always be shorter than the old one.

Remark 2.- If the new tangent, or its extension back-

g k k b b d

ward, cuts the old radius, a e, as in Fig. 33, this problem does not apply. In such cases, the startingpoint, a, must be moved. See Arts. XXVIII. and XXX.

RULE.

Ist. Place the instrument at b, and measure the angle d b c formed by the old and the new tangents.

2d. Find the new central

angle a g i (subtended by the entire new curve a i) = a e b minus d b c, when, as in Fig. 35, the new tangent, b d, deflects outward at b; or = a e b plus d b c, when, as in Fig. 36, it deflects inward.

3d. Find $ex (= k w) = \text{radius } a e \times \text{ver. sine of } d b c$.

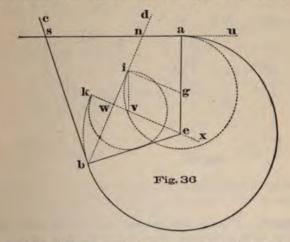
4th. Find ge, the difference between the old and the new radius $= ex \div \text{ver. sine of } a gi \text{ or of } u n d$.

5th. Find the new radius ag = old radius ae - ge.

DEMONSTRATION.

To show that ex is = radius $a e \times$ versed sine of d b c, see demonstration of Art. XXVIII.

To show that g e is $= e x \div \text{versed sine of } a g i$; from i draw i v, parallel and equal to g e. Now, i v and k v being respectively parallel to a g and i g, the arc i k is = arc a i, and the angle i v k is = angle a g i. Also, k w



(=ex) is evidently $=iv \times$ versed sine of iv k ($=ge \times$ versed sine of agi). In other words, ge is $=ex \div$ versed sine of agi.

ARTICLE XXX.

Having from a, Figs. 37 and 38, run a curve, ab, to b, where it is tangential to b c, we wish to change the radius and the starting-point, so as to strike the divergent tangent, b d, at the same point b.

Required the new radius fg and the distance af. See footnote to Art. XXVI.

Rule.—For the new radius fg.

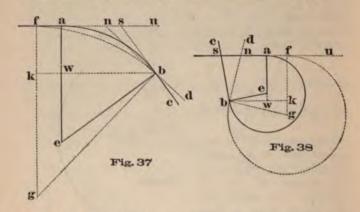
1st. Place the instrument at b, and measure the angle d b c.

2d. Find the new central angle fg b, subtended by the entire new curve f b, thus: If, as in Fig. 37, the new tan-

gent, b d, deflects outward, then fg b (= u n d) is = old central angle a e b minus d b c. But if, as in Fig. 38, the new tangent, b d, deflects inward, then fg b =old central angle a e b plus d b c.

3d. Find $f k (= a w) = \text{old radius } a e \times \text{ver, sine of } a e b$.

4th. Then new radius $fg = fk \div \text{ver. sine of } fg b$.



Remark.—Having now the new radius, it is plain that nothing more is necessary than to run the new curve, fb, backward, beginning at b. This will, of course, bring us to f, without any special calculation for finding af. It may, however, be found thus:

1st. Find bk (= new radius $fg \times \text{sine of } fgb$).

2d. Find $bw (= \text{old radius } ae \times \text{sine of } aeb)$.

3d. Find af, thus:

If aeb and fgb are both greater (as in Fig. 38), or both less (Fig. 37), than 180°, then

af is = the difference, kw, between bk and bw.

If either a e b or f g b is greater, and the other less, than 180°, then

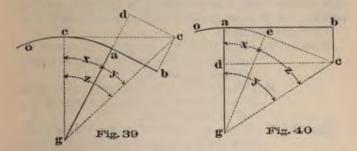
af is = the sum of bk and bw.

4th. From a, measure af along sa; toward b if the new radius is less than the old; and away from b, if, as in Figs. 37 and 38, the new radius is greater than the old.

ARTICLE XXXI.

Having run a curve from o to a, Figs. 39 and 40, and then a tangent to b, we wish to find a new point, e, on the curve, such that a new tangent, e c, shall pass through a point, c, at a given distance, b c, at right angles to a b.

In Fig. 39, the point c is outside the tangent a b; and in Fig. 40 it is inside.



Required, to find the angle x, which is the number of degrees to go backward along the curve from a to e, in

Fig. 39; or forward in Fig. 40.

Rule.—Complete the rectangle, abcd, thus making dc = ab; and ad = bc; and thus finding gd,= the sum of ga and ad in Fig. 39; and = their difference in Fig. 40.

Find the angle y, by means of its tangent $\frac{d}{g}\frac{c}{d}$. Find its sine.

Find $eg = dc \div \text{sine of } y$.

Find the angle z, by means of its cosine $\frac{e g}{c q}$.

Find the angle x, = the difference between y and z.

This x is the number of degrees from a to e; and consequently $\frac{x}{\text{chord-deflection angle}}$ is = the number of chords from a to e.

ARTICLE XXXII.

Having from a laid out a simple curve to b, Figs. 41 and 42, and at b changed it to a compound curve by adding b c, so that at c it terminates in the tangent cn; it is

Required to find a new point, k, of compound curvature, so that the compound curve, akf, traced with the same radii as before, may terminate, as at f, in a new tangent, f m, parallel to the first one, cn, and either outside or inside of it.

There are two cases:

Case I.—A. (Fig. 41) When the curve of shorter raradius is run first, and the tangent sought is *inside* the first one.

> B. (Fig. 42) When the curve of longer radius is run first, and the tangent sought is outside of the first one.

Case 2.—C. When the curve of shorter radius is run first, and the tangent sought is outside of the first one.

> D. When the curve of longer radius is run first, and the tangent sought is inside of the first one.

If we suppose the first branch, a b, of the curve, to be extended forward to a point, t, where it would be tangential to jv, parallel to the two tangents, cn and fm; then:

Case 1, as in our figs., is when j v and f m are on the same side of cn; and

Case 2 is when j v and f m are on opposite sides of c n. Remark.—In Case 1, the tangent fm sought, must lie between the first tangent c n and the tangent j v to the first branch extended. Otherwise this problem does not apply, and the radii must be changed.

Both our figures illustrate Case 1, but by changing the

lettering they can be made to answer for Case 2.

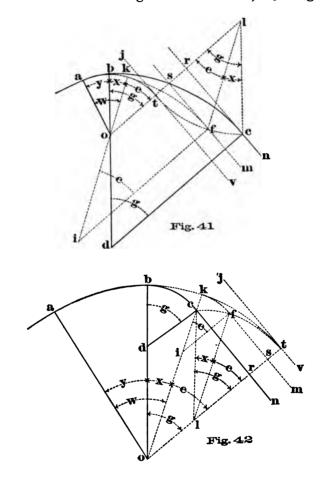
In both figures we have denoted equal angles by the same letter, without reference to their position in the figure.

Rule, both in Case 1 and in Case 2.

1st. From the Table, p. 170, take the versed sine of the

central angle, g, subtended by the second branch, $b\ c$, as first run.

2d. Measure on the ground the distance, rs, at right



angles between the tangents cn and fm. Divide rs by the difference, do, between the radii. Call the quotient $\frac{rs}{do}$.

3d. Find the new central angle, e, for the second branch, kf, by means of its versed sine, which is equal

in Case 1 to the versed sine of g minus $\frac{r}{d}$; and

in Case 2 to the versed sine of g plus $\frac{r}{do}$.

Remark.-If, in Case 2, this sum exceeds 2, either the radii or the starting-point, a, must be changed, and this

problem does not apply.

Remark.—Either of the two angles given by the table for a versed sine, found as above, may be taken as e: but the one nearest equal to g will give the shortest distance to run backward or forward from b.

4th. Now, as the tangents c n and f m are parallel, the total central angle will be the same after the change as before it. In other words (w+e) will be equal to (y+q). In order to bring this about, we must increase y just as much as we diminish q, and vice versa.

Therefore, find x, which is equal to the difference between g and e, find the number of chords in b k, which is

= chord-defl. angle of first branch ab; and from b lay off this number of chords, forward if g is greater than e, backward if e is greater than g.

Remark.—If, in going backward from b, we find that x exceeds y, we must change the radii or the point a.

Example.—Case 1. Suppose a 2° curve (radius 2865 feet) followed by a 3° one (radius 1910 feet), the second branch having a central angle of 36°. It is required to strike a tangent 20 feet outside the present one.

Here, versed sine of 36° minus diff. of radii (955) versed sine of new central angle.

Or, 1910 minus 0209 = 1701 = versed sine of33° 54'.

And $36^{\circ} - 33^{\circ} 54'$ is $= 2^{\circ} 6'$, which is $= 1_{757}$ chords

of a 2° curve. Therefore go forward 1 5 chords from b, with first radius a o, to k.

Case 2. Suppose a 2° curve followed by a 3° one;

central angle of second branch 36°. It is required to strike a tangent 20 feet *inside* the present one.

Here, versed sine of $e = \text{versed sine of } g \text{ plus} \frac{r s}{d o} = .1910$

$$+\frac{20}{955}$$
 = .1910 + .0209 = versed sine of 38°.

And $g-e=38^{\circ}-36^{\circ}=2^{\circ}=1$ chord of a 2° curve. Therefore, go back 1 chord from b with first radius, a o, to k.

DEMONSTRATION

of Case 1, by Figs. 41 and 42.

From c, where the old second branch, b c, joins its tangent, c n, draw c l parallel to d o, the difference between the radii, and evidently equal to it; thus making c l t equal to g. As c r is perpendicular to o t, r t is = d o \times versed sine of g.

From f, where the *new* second branch, kf, joins its tangent, fm, draw fl parallel and equal to oi, and equal to do. Then will flt be =e; and st will be $=do \times$ versed sine of e. Now st is =rt-rs: in other words, $(do \times versed sine of <math>e$) is $=(do \times versed sine of <math>g)-rs$.

Hence we have, as in "3d" of the rule,

Versed sine of e = versed sine of $g - \frac{r s}{d o}$.

ARTICLE XXXIII.

Having from b or d run a curve, b x o, or d y t, Figs. 43 and 44, of known radius, and central angle, b c o or d n t, we wish to change the radius, so that the new curve shall, at its middle point, x or y, be a given distance, x y, from the old one.

Required the new radius and b d.

Case I, Fig. 43. When the central angle is less than 180°.

A .- When the outer curve, b x o, has been run first.

RULE.

1st. Find $ac = \text{radius } bc \div \text{cosine of } bca = \text{radius } bc \div \text{cosine of } half bco.$

2d. Find ax = ac - rad. b.c.

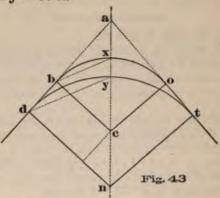
3d. Find ay = ax + given distance xy.

4th. Find new radius, dn, thus:

ax:ay:: old rad. bc: new rad. dn.*

5th. Find $b d = (d n - b c) \times \text{tangent of } b c a$.

Example.—Let rad., bc, of the curve, bxo, first run, be 300 ft.; the central angle, $bco = 100^{\circ}$; and the given distance, xy = 80 ft.



Then we have,

1st. $ac = \text{radius } bc \div \text{cosine of } bca = bc \div \text{cosine } 50^{\circ}$ = 300 \div .6428 = 466.7 ft.

2d. ax = ac - bc = 466.7 - 300 = 166.7 ft.

3d. ay = ax + xy = 166.7 + 80 = 246.7 ft.

4th. ax:ay:: 166.7: 246.7:: bc:dn:: 300:444. dn=444.

5th. $bd = (dn - bc) \times \text{tang. } bca = cn \times \text{tang. } 50^{\circ} = (444 - 300) \times 1.19175 = 144 \times 1.19175 = 171.6 \text{ ft.}$

B. When the inner curve dyt has been run first.

RULE

1st. Find $an = dn \div \text{cosine of } dn = \frac{dn}{\cos \frac{1}{2} dn t}$

2d. Find ay = an - dn.

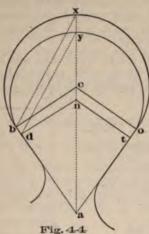
3d. Find a x = a y - x y.

^{*}Because by similar triangles, as ax : ay :: ab : ad; and as ab : ad :: bc : dn.

[†] Because ad is $=dn \times tang$. of dna or bca; and $ab=bc \times tang$. of bca; and $db=ad-ab=(dn-bc) \times tang$. of bca.

4th. ay:ax::dn:bc. 5th. $bd = (dn - bc) \times tang$. of dna.

Case 2, Fig. 44. When the central angle exceeds 180°.



Rule.—Subtract the central angle $b\,c\,o$, or $d\,n\,t$ (subtended by the curve), from 360°; and use the remainder

(which will be our "substitute angle," or the *smaller* angle b c o or d n t) as a substitute for it; proceeding precisely as in the foregoing A and B, with the following exceptions:

(A.) When the outer curve, b x o, has been run first,

a x will be = a c plus b c; and a y will be = a x minus x y.

(B.) When the inner curve, dy, has been run first, ay will be = an plus dn; and ax will be = ay plus xy.

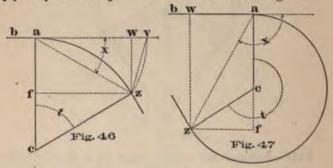
Fig. 45

Remark.—Fig. 45. When the central angle is precisely 180° ; it is evident that the radius remains unchanged, and that the dist b d is = x y.

ARTICLE XXXIV.

To find what radius, a c, Figs. 46 and 47, a curve a z, starting at a, must have, and how many chords it must run; in order to pass through a point z, at given distances, w z, at right angles to the tangent b a; and f z, or a w, at right angles to a f; in front of a, Fig. 46, or behind a, Fig. 47.

Rule.—Divide wz by aw. The quotient will be the tangent of x. From the table, p. 124, take x,* and multiply it by 2. The product will be the central angle t.



Then radius $a = \frac{fz \text{ or } aw}{\text{sine of } t} = \frac{af \text{ or } wz}{\text{versed sine of } t}$

And $\frac{\text{angle } t_*}{\text{chord-def. angle}} = \text{number of chords of curve}$ from a to z_*

ARTICLE XXXV.

To find how far aw, Figs. 46 and 47, from w to start a curve az of given radius, ac, in order to pass through a point z, at a given distance, wz, at right angles to the tangent ba; in front of a, Fig. 46, or behind a, Fig. 47.

Rule.—Divide wz by the radius ac. The quotient will be the versed sine of central angle t. From the table, p. 170, take the angle t. \dagger

Then a w = rad, $a c \times \text{sine of } t$.

^{*} In Fig. 47 take the tabular x from 180°, for the true x. † In Fig. 46 t is the lesser of the two angles in the table; in Fig. 47, the greater.

ARTICLE XXXVI.

To find how far, w z, Figs. 46 and 47, a curve, a z, of given radius, a c, will be from, and at right angles to its tangent, b a, after running a given number of chords.

Rule.—Multiply the chord-deflection angle by the given number of chords. The quotient will be the central angle t.

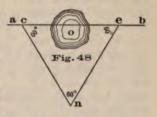
Find the versed sine of t, in table, p. 170. Then wz is = radius $ac \times ver$. sine of t.

ARTICLE XXXVII.

To Pass or Clear Obstacles.

Mode 1, Fig. 48. Suppose that in running a straight line from a towards b, we meet with an obstacle, o, which may be a deep pond, or a building, etc. To pass it, at any convenient point c in the line ab, lay off an angle c of

60°, thus sighting along cn. From c measure cn sufficiently long to clear the obstacle. Remove the instrument to n, and lay off another angle of 60° , thus sighting along ne. Make ne as long as cn. Then e will be in the straight line ab; and its distance from e will be equal



to cn or ne. From e take sight at n; lay off the angle nec, 60°, or the angle neb, 120°, and then the telescope will sight along the line ab, which we are running. This is perhaps the neatest and most expeditious mode of proceeding in such cases.

Remark.—If any other angle than 60° is used at c, then the angle e must be made = c. The angle n must be made $= (180^{\circ}$ — the sum of e and e), and the dis-

tance, ce, will be $= c n \times 2 \times \text{cosine of } c$.

Mode 2, Fig. 49. At times this may be found more applicable than Mode 1, although a little more troublesome, as it requires four angles of 90° instead of three of 60° . Running from m towards r we have to clear the obstacle

d. At any convenient point o on the line m r, lay off the angle 90°, thus sighting towards v. Measure off any distance o v sufficient to clear the obstacle. Move the instru-

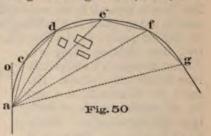


ment to v, and make the angle at v 90°; thus sighting along vw. Measure vw long enough to clear the obstacle. Move the instrument to w, and lay off the 90°, thus sighting along ws. Make ws as long as ov. Then

s will be in the straight line m r; and its distance from o will be equal to v w. Move the instrument to s, and lay off the angle w s o or $w s r = 90^{\circ}$; and then the telescope will sight along the line m r which we are running.

Mode 3.—By long chords, Fig. 50. Having run a curve from a to d by tangential angles o a c, c a d, and

with 100 ft. chords a c, c d, we find that an obstacle prevents our sighting to e. In that case we omit of measuring the two chords d e, e f, and leaving e to be fixed a by some other process, we go on to f,



thus: Lay off the tangential angles dae, eaf, as if no obstacle existed; and sighting along af, make it a long chord corresponding to four stations, ac, cd, de, ef, and to the radius of the curve, as per our Table of Long Charles af

Or after sig

Or, after sighting from a to f, measure from d to f a long chord df (not shown in the fig.) corresponding to two stations de, ef, as per the same table, fixing the end f by the instrument at a. The curve may then be continued from f by tangential angles, fag, etc., and 100 ft. chords, fg, etc., as at first.

Mode 4.—To carry either a tangent, b f, Fig. 51, or any curve (whether simple, compound, or reverse), past

an obstacle o.

Running a line from k we meet the obstacle o. To pass

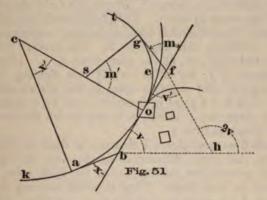
it, select any point, a, in the line (which is here a curve), as near as convenient to the obstacle. Knowing the distance, a o, in chords, find the central angle, x' = number of chords \times chord-deflection angle.

Find the apex distance, a b or $o b = \text{radius } c a \times \text{tan}$

gent of half x'.

Place the instrument at a; lay off a tangent ab; upon it measure off the apex distance ab; and drive a stake at b.

Then b is a point in the tangent bf.



Remove the instrument to b; take sight on a, and lay off the angle x = x'. Revolve the telescope, thereby

sighting in the direction of the tangent b f.

Lay off, on either side of bf, any angle v (which had better, if possible, be just 60°), and any measured distance, bh, that will serve to clear the obstacle. Drive a stake at h.

Remove the instrument to h; take sight on b; revolve the telescope; lay off the angle 2v = twice v, thus sighting along hf.

Make hf = bh. Drive a stake at f, which will then

be a point in the tangent bf.

If the angle v has been made 60° , fb will be = hf or bh; otherwise we must calculate fb, which is $= bh \times cosine$ of $v \times 2$.

Remove the instrument to f; take sight on h, and lay off the angle v' = v; thereby sighting along the tangent fb.

Now, if the curve ends at o, this tangent is, in itself, all we want; but if the curve (either simple, compound, or reverse, as represented by the three curves beyond o) is to be continued beyond o, we proceed in either of the three cases, and by the same process, first, to find a point in the curve beyond o; and then to run the curve in either or both directions from that point. For illustration we shall select the curve ot, and show how to find a point, q, in it.

On the tangent fb take any convenient point, as f, at a known distance, fo, from o.* Divide this fo by the radius, os, of the curve to be run. The quotient will be a natural tangent. From the table take out the angle corresponding to it. Multiply this angle by 2. The product will be the central angle, m', of the part curve, oeg. Place the instrument at f; lay off m (= m') thus sighting in the direction fg; and make fg equal to the known distance fo. Then is g a point in the curve; and fg is a tangent to the curve at g. Hence it is easy to run the curve in either direction from g.

Mode 5 accomplishes all that can be done by Mode 4, even in case some obstruction, as the river in Fig. 52, should prevent our making use of the apex point, b, so essential in that Mode. Thus if, when running from k towards f, we meet an obstacle, o, we imagine a stake, f, to be driven on the tangent, at a given distance, f o, from and beyond the obstacle, such that f could be seen, and af measured from a. We then calculate the angle b af, and the distance a f, both of which being laid off from a, plainly enables us to place an actual stake, f, in the tangent.

In the first place, to find the angle b a f, knowing the length in chords of the part curve, a e o, we can find its central angle, x, and its apex distance, b a or b o; also the angle a b f = 180° — x. Therefore, in the triangle a b f, we have given two sides, a b and b f (the last = b o + the given distance, f o); and the angle a b f; to find the angle b a f and the side a f.

Now we know the sum of the two angles b a f and b f a to be $= 180^{\circ} - a b f$. Call this sum s; and call their unknown difference, d. After finding d, then half of s + 1

^{*} If we select the point f, just found, we know that $f \circ is = fb - ob$.

half of d will equal the larger angle $(b \ a \ f)$; and half of s — half of d will equal the smaller one $(b \ f \ a)$, which also will be needed after finding f.

Now to find d, we use the well-known trigonometrical

rule,

Sum of the two given sides . Their tang. of half of s half of d.

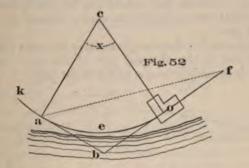
Having in this way found the angle b a f, find the distance a f, by another familiar trigonometrical rule,

Sine of bfa, opposite the given side, ab:

Sine of abf, opposite the reqd. side, af:

The given side, ab:

The reqd. side, af.



Having found and measured off the distance, af, and driven a stake at f, move the instrument to that point; take sight on a, and lay off the angle bfa. The telescope will then sight along the required tangent, fb.

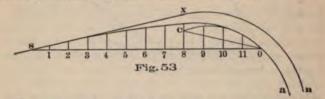
From any point on this tangent any kind of curve may be commenced, if required, or may be continued from the

point o, as in Fig. 51, Mode 4.

ARTICLE XXXVIII.

The object in easing off the ends of curves, that is, in gradually increasing the radius near the ends, is to enable trains to leave the straight line less abruptly, and thus to reduce the momentary jar so commonly felt at the instant of entering a curve, especially when of short radius, and at high speed. This jar, which is not only unpleasant to passengers, but damaging to engines and cars, is owing to the flanges at first striking an oblique blow against the outer rail of the curve. After this blow has been struck, the subsequent steady pressure against the outer rail is comparatively harmless; and indeed may be greatly increased by a gradual sharpening of the curve, without any repetition of jar.

The great point, therefore, is to carry the train from the straight line to the sharpest part of the curve, with a steadily increasing pressure, and without jar.



The writer believes that the following simple process will be found to answer sufficiently well in practice, although many may consider it very crude in theory, inasmuch as it always gives the same distance for effecting the change.

Its execution in the field is extremely simple, which is an important point in such matters. It applies to the sharpest curve that can be traced with 100 ft. chords, as well as to the flattest one in which easing off of the ends will be at all likely to be considered expedient; say one of from 3,000 to 4,000 feet radius.

Rule.—Let x n, Fig. 53, be part of the curve; and x s its tangent. Divide the chord-deflection distance (Table, p. 18) by 10. The quotient will be c x. Set every stake of the entire curve inward this distance, c x, so that the

curve shall be removed to ca.* The radius of the curve is thus evidently shortened to the extent of cx; but this is of no importance. From x measure on the tangent 100 feet to s; and from c measure 50 feet to the curve at o.

Either stretching a piece of twine from s to o, or ranging along so with the transit, lay off the 11 equidistant ordinates, if for rail laying; or only the middle one (6), or it and the two quarter-way ones (3 and 9), if for grading.

Since xs is always 100 feet, and co 50 feet, the distance apart of these 11 ordinates will always be nearly 12.5 feet.

The ordinates themselves in feet are found for any curve, by multiplying ex by the following

MULTIPLIERS.

| Ord. | Mult. | Ord. | Mult. | Ord. | Mult. | Ord. | Mult. |
|------|-------|------|-------|------|-------|-----------|-------|
| 1 | .180 | 4 | ·645 | 7 | .975 | 10 | .715 |
| 2 | .355 | 5 | .775 | 8 | -990 | 11 | •430 |
| 3 | .505 | 6 | 890 | 9 | .905 | 1 1 2 2 2 | 1000 |

Example.—Let x n, Fig. 53, be part of a 6° curve, or 955.4 radius, and x s its tangent. Its deflection distance (Table, p. 20) is then 10.47 feet; one-tenth of which, or 1.047 feet, is cx. Move all the stakes of the entire curve inward 1.047 feet, as along coa.† From x measure 100 feet to s; and from c measure co, 50 feet, to the curve; driving stakes at s and o. Multiply cx, or 1.047 feet, by the above multipliers; thus finding the following 11 ordinates, of which lay off as many as are needed.

necessity for removing them, or for shortening the radius.

† The table of cx in feet below shows that even very sharp curves require to be moved inward but a short distance.

| Deg. | Rad. Feet. | e x. Feet. | Deg. | Rad. Feet. | e x. Feet. | Deg. | Rad. Feet. | e x. Feet. |
|----------------|--------------------------|------------------------------|----------------------------|---------------------------|-----------------------------|----------|------------------------------|--------------------------|
| 19 ° 14 11½ 9½ | 303 410 499 604 | 3·30 2·44 2·00 1·66 | 810 7 53 43 43 | 695 819 997 1207 | 1·44 1·22 1·00 ·83 | 4° 3 2 1 | 1433 1910 2865 5730 | ·70 ·52 ·35 ·17 |

^{*}Or, which would be much better, the curves may be traced inside of their tangents during the definite location, thus avoiding the necessity for removing them, or for shortening the radius.

| Ord. | Ord. | Ord. | Ord. |
|---------|---------|----------|------|
| 1.=:188 | 4.=.675 | 7.=1.021 | |
| 2.=:372 | 5.=.811 | 8.=1.037 | |
| 3.=:529 | 6.=.932 | 9.= .948 | |

ARTICLE XXXIX.

Resistance of Curves.

The following will merely give some general idea of the principles involved in investigating this most intricate

and practically unsolvable subject.*

The resistance which curves oppose to the passage of trains is influenced by many circumstances; such as the velocity; radius of the curve; wind; diameter of the wheels; shape of the wheel-treads, whether more or less conical; by the distances apart of the several pairs of wheels; by whether the cars are empty or loaded, for an empty train offers greater resistance than a loaded one of the same weight; by the kind of coupling; by the width of track; its condition; the degree of elevation of the outer rail: the length of the train, for a long train experiences proportionately more resistance than a short one, owing to the obliquity of the traction, etc., etc. From the want of sufficient experimental data, the subject is but imperfectly understood, and consequently all calculated results are more or less liable to error. Our own opinion is that the resistance has been usually underrated. So far as we can judge from the incomplete and contradictory experiments and observations that have been recorded, we are inclined to believe that at the speed of about 25 miles per hour, on a track in good order, and with trains equal to from 6 to 10 eight-wheeled cars, we may assume, as a rough approximation, that a level curve of 400 feet radius will oppose a resistance of about 15 lbs. for every ton weight of the train, in addition to the resistance on a

^{*}Of late years much has been written on the subject of the influence of curves and grades; by none more ably than by Mr. Arthur M. Wellington, Civ. Eng., to whose "Economic Theory of the Location of Railways," published by the "Railroad Gazette," 73 Broadway, N. Y., we refer those desiring information.

level straight line. On a level straight line, in good order, and in calm weather, the resistance at 25 miles per hour is about 12 lbs. per ton. On these assumptions, therefore, the total resistance on a level curve of 400 feet radius, at 25 miles per hour, would be 27 lbs. per ton, or 2½ times

as great as on a straight line.

Now, the assumed additional 15 lbs. per ton, due to curvature, or deflection, alone, without any regard to distance, is the the part of a ton; and the the part of a mile is 35.36 feet; being that grade, or inclination, which, by the principle of the inclined plane, increases the gravity resistance of a ton, or of any other weight, the Talia part. Therefore, our ascribed resistance for a radius of 400 feet, at 25 miles per hour, is equal to that of an upgrade of 35.36 feet per mile; or, 670 of a foot per 100 feet. If, in addition, we assume, as is usual, but probably incorrect that at the same speed the resistance of curves is as the tabular angle of deflection, or inversely as the radius (although some experiments seem to show that the increase is much more rapid), we arrive at the results given in the following table; and which are probably at best but rude approximations. They are about one-sixth part greater than our suggestion for reduction in the Table on p. 95. Which is nearest the truth, we are unable to say,

TABLE OF RESISTANCES

(IN EXCESS OF THOSE ON A STRAIGHT LINE) DUE TO CURVA-TURE ALONE; AT A VELOCITY OF 25 MILES PER HOUR.

For the total approximate resistance, add 12 lbs. to each amount in the third column; 28.4 feet to each grade per mile; and 538 of a foot to each grade per 100 feet.

| - | Radius. | | rox. | Resist. per ton, from cur- vature alone. | Equiva upgra in fe | de; | Radius. | ang | orox. | Resist, per ton, from cur- vature alone. | Equiv upgra in fe | ade; |
|---|---------------------|-----|----------|--|--------------------------|----------------|--------------|-----|----------|--|-------------------------|----------------|
| 1 | Feet. | D. | M. | Pds. | Per mile. | Per 100 ft. | Feet. | D. | M. | Pds. | Per mile. | Per 100 ft. |
| | 400 | | 22 | 15 | 35.36 | .670 | 2400 | 2 | 23 | 2.5 | 5.89 | 112 |
| | 500 600 | 9 | 30 34 | 12 10 | 28·29 23:57 | ·536 ·447 | 2600 2800 | 2 2 | 12 2 | 2·31 2·14 | 5·44 5·05 | ·103 ·096 |
| | 700 800 | 8 7 | 12 | 8·57 7·5 | 20.21 | ·383 | 3000 | 1 | 54 47 | 2 1.88 | 4·71 4·42 | 089 |
| | 900 | 6 5 | 22 43 | 6.66 | 15·72 14·14 | ·298 ·268 | 3400 | 1 | 41 35 | 1.76 1.67 | 4·16 3·93 | ·079 |
| | 1100 1200 | 5 4 | 12 47 | 5·45 5 | 12.86 11.78 | ·244 ·224 | 3800 4000 | | 30 26 | 1.58 1.50 | 3·72 3·54 | 071 |
| | 1300 1400 | 4 | 25 | 4·64 4·28 | 10.94 10.11 | ·208 ·192 | 4200 4400 | 1 | 22 18 | 1·43 1·36 | 3·38 3·22 | 064 |
| | 1500 | 3 | 49 | 4.02 | 9.48 | 180 | 4600 | 1 | 15 | 1.30 | 3.08 | 058 |
| | 1600 1800 | 3 | 35 11 | 3·75 3·33 | 8·84 7·86 | 168 | 4800 5280 | 1 | 12 5 | 1·25 1·14 | 2.68 | 056 |
| | $\frac{2000}{2200}$ | 2 2 | 52 36 | 3 2.72 | 7·07 6·43 | 134 | 5730 6000 | 1 0 | 0 57 | 1.05 | 2·47 2·36 | 047 |

For ease of recollection, we may, according to this, consider the resistance of curvature alone, at 25 miles per hour, as about 1 lb. per ton for each degree of chord deflection angle. If, on ascending grades, we wish to equalize the traction on curves, and on straight lines, for a speed of 25 miles per hour, we must flatten the grades on the curves at the rates given in the last two columns. But since the resistance of curvature is affected by the velocity, it plainly follows that the flattening which is best for fast passenger trains, cannot also be best for slow freight; so that, even if we could determine a precise law of resistance, we could not so apply it as to suit both. So far as we are aware, there are no absolutely reliable data on the additional resistance of curves at different speeds.

Some have supposed it to be independent of the velocity; but it has generally been assumed to increase in some proportion to it; but Mr. Wellington found "that the additional resistance of a 1° curve is over 1 lb. per ton (2000 lbs.) at a velocity of 12 miles per hour, and decreases to about ½ lb. per ton at a velocity of 22 miles per hour. The resistance of an 8° curve was over 8 lbs. per ton at a velocity of 9 miles per hour, and decreased to about 6½ lbs. per ton (probably) at a speed of 19 miles per hour."

These unexpected results are in accord with Professor Thurston's discovery that journal friction decreases at high

velocities.

On the Pennsylvania R. R. the grades were originally flattened on curves, at the rate of from full 1 foot per mile, on moderate ones, to 1½ foot on the steeper ones, for each 1° of chord deflection angle of the curve; but experience on that road at speeds less than 25 miles per hour showed this to be too little.

Perhaps until we can with certainty do better, we may, for any velocity, reduce the grade on curves at the rate of ·04 of a foot per 100 feet (2·112 ft. per mile), for each degree of chord angle of deflection (p. 18), as shown in the last two columns of the following table; or about one-seventh part less than in the preceding one.

Remark.—Since the reduction of grade is often difficult to accomplish without much expense, it seems scarcely worth while to do it at all in such cases (or indeed in others), except when, without it, the curves would tax the

power of the locomotives unduly.

TABLE FOR THE REDUCTION OF GRADES ON CURVES.

| Deg. | Rad. | Per Mile. | Per 100 ft. | Deg. | Rad. | Per Mile. | Per 100 ft. | Deg. | Rad. | Per Mile. | Per 100 ft. |
|------|--------------|------------------|----------------|----------|------------|------------------|----------------|----------|------------|------------------|----------------|
| 1 | 5730 | 2.112 | -04 | 9 | 637 | 19.008 | *36 | 17 | 338 | 35.904 | -68 |
| 2 3 | 2865 1910 | 4·224 6·336 | 08 | 10 11 | 574 522 | 21·120 23·232 | ·40 ·44 | 18 19 | 320 303 | 38·018 40·128 | ·72 ·76 |
| 5 | 1433 1146 | 8.448 10.560 | 16 | 12 13 | 478 442 | 25°344 27°456 | '48 '52 | 20 21 | 288 274 | 42°240 44°352 | ·80 ·84 |
| 6 | 955 819 | 12.672 | -24 | 14 15 | 410 383 | 29·568 31·680 | ·56 ·60 | 22 23 | 262 251 | 46·464 48·576 | ·88 ·92 |
| 1 8 | 717 | 14·784 16·896 | ·28 ·32 | 16 | 359 | 33.792 | 64 | 24 | 241 | 50.688 | .96 |

Remark.-It is plain that, when the grades are very

moderate, and the curves at the same time sharp, the grades cannot be reduced sufficiently to compensate for

curvature; so also when the road is level,

Many of the principal railroads, both in the United States and in Europe, have some curves with very small radii. On the Pennsylvania R. R. are several, of from 637 to 717 feet radius. The Reading has several of 800 feet. On the New Jersey Central is one of 400 feet. On the Baltimore and Ohio are many of from 400 to 600 feet. On all these roads, however, the curvature is being reduced at heavy expense. On the Lehigh Valley road is a curve of nearly a semicircle, the ends of which have radii of 717 feet, thence gradually decreasing both ways toward the center, where it is only 359 feet. About half this curve has a grade of 10 feet per mile, and the other half has 30 feet; both in the same direction. Descending trains of 110 four-wheeled loaded coal-cars (900 tons in all) have no difficulty in passing the curve; but if the empty trains stop on ascending, they frequently have great trouble to start again, and then resort to sanding the rails.

On the Mahanoy and Broad Mountain road, tank engines of 35 tons, all on 8-drivers, draw 40 empty coal-cars, weighing 100 tons, up a continuous grade of 175 feet to a mile, for 3½ miles, around an almost constant succession of curves of from 450 to 600 feet radius, at 8 miles an

hour, as a regular business.

When the radius is less than about 1000 feet, the width of the track should be slightly increased, otherwise the wheels of the train are apt to bind between the rails and break. About an inch will answer for this purpose on a curve of 400 feet radius; \(\frac{3}{4}\) inch for 600; \(\frac{1}{2}\) inch for 800; \(\frac{1}{4}\) inch for 1000, as a purely empirical approximation.

Curves are especially objectionable in deep cuts and on steep grades. In the former they prevent the driver from seeing ahead; and when descending the latter there is greater danger of leaving the track, inasmuch as the speed of the engine is not under as perfect control; especially with slippery rails.

The coning of the treads of the wheels tends theoretically to diminish the resistance of curves, by virtually enlarging the diameter of the outer wheels to a degree

commensurate with the greater distance they have to travel along the outer rail. The elevation of the outer rail. by counteracting the centrifugal force, still further reduces the resistance. But unfortunately these aids cannot be so applied as to suit the different velocities of fast and slow trains. If, as is always done (with a view to the safety of passengers), they are adapted for fast trains, then they produce an opposite effect upon the slow ones, which, for want of sufficient centrifugal force, slide down the inclined plane formed between the two rails, until the lower flanges rub against the inner rail. When this takes place, the inner wheels not only have a less distance to travel than the outer ones, but, their diameter becoming enlarged, they must evidently slide, as well as revolve, in order to keep pace with them. This sliding produces a dangerous twisting, or torsional, strain upon the axles, rendering them liable to break, especially if the cars are heavily loaded.

Moreover, even when the coning of the treads enables the cars to run more easily around curves, it adds to the resistance upon straight lines. Inequalities of the track then cause the train to run in a zigzag line, pressing the flanges alternately against the opposite lines of rails. On this account the coning has of late years been much reduced, until at present it rarely exceeds 1 in 20; and on some of our principal roads it is but 1 in 50. Finally, the cone is soon worn off by use, and the wheels become

cylindrical.

ARTICLE XL.

On the Elevation of the Outer Rail on Curves.

When a train is going around a curve, the centrifugal force throws it *outward* against the outer rail; and this force increases *directly* as the square of the speed, and *inversely* as the radius. To counteract it, an *inward* tendency is given to the train by placing it, as it were, upon an inclined plane formed by raising the outer rail above the inner one.

It is evident that theoretically each velocity requires its corresponding elevation; but inasmuch as this cannot be effected in practice, the elevation is proportioned to the greatest probable speed, in order to secure the safety of passengers. Slow freight trains will then slide down the inclined plane; and the flanges of their wheels will rub against the inner rail, and wear it more rapidly than the

outer one; but this must be submitted to.

On the other hand, a great elevation of the outer rail causes the cars to lean sideways to a degree that is disagreeable to passengers; and liable to displace freight. Therefore a limit of about 6 inches on 4 ft. 8½ in. gauge is usually assumed as the greatest elevation to be given in any case; and where the curves are so sharp that this is not enough for safety at great speed, orders are given to diminish the speed. This would answer very well if the orders could always be enforced; but as this cannot be done, it involves an element of danger that can be averted only by the adoption of easy curves.

Either of the two following formulas gives the elevations in the next table. Both might be greatly and uselessly complicated by admitting the coning of the wheel and other considerations; but these refinements may safely be

discarded.

Formula 1.—Elevation in inches
$$\frac{\text{Square of speed}}{\text{In feet per second}} \times \frac{\text{gauge}}{\text{in inches}}$$
Formula 2.—Elevation in inches
$$\frac{\text{Square of speed}}{\text{Radius in feet}} \times \frac{\text{gauge}}{\text{in miles per hour}} \times \frac{\text{gauge}}{\text{in feet}}$$
Radius in feet \times 1.25

The common gauge of 4 ft. 81 ins. is equal to 4.7083

feet, or to 56.5 inches.

Remarks.—While speed was restricted to about 35 or 40 miles per hour, the rule of thumb, of half an inch elevation for each degree of chord deflection angle, seems to have answered very well, although but half of what the formulas require, as seen in our table, in the column for 40 miles speed. But of late years this has, on many leading roads, been increased to 1 inch per degree of chord deflection angle, to meet the increased speeds of 50, 60, or more miles per hour, which are becoming not unfrequent; more than 80 have in fact been accomplished. The maximum elevation, however, is still limited to about 6 inches on 4 ft. 8½ in. gauge.

It will be seen that on any curve in our table (from 1° to 40°, or from 5730 to 146 ft. radius), the rule of 1 inch per degree is safe at a speed of nearly 40 miles per hour; but that after 6°, or with less radius than 955 feet, the above limit of 6 inches is exceeded. There can, however, be no doubt that where the elevation has been but ½ an inch per degree, trains have daily travelled curves at 40, and, perhaps, at times, at 50 or more miles per hour; and that even where there was no elevation at all, but where the formulas call for about 3 to 3½ inches, as on turnouts of only 700 to 800 ft. radius, they have habitually run at 25 or more miles per hour.

These facts, however, do not invalidate the principle of

the formulas.

Our following table indicates that at 1 inch per degree, with a limit of $6\frac{1}{2}$ inches total elevation, a 1° curve would be safe at 100 miles an hour; a 2° one at 70 miles; a 3° one at near 60; a 4° one (1433 ft. rad.) at 50; a 6° one (955 ft. rad.) at 40; and a 10° one (574 ft. rad.) at full 30 miles.

Our table is for the standard gauge of 4 ft. 8½ ins.; for greater or for less gauges the elevation will increase or diminish directly as the gauge; thus maintaining the same rate, or angle of elevation in all cases.

The elevation must, of course, be made gradually.

When the curve is uniform, that is, when its ends are not eased off by larger radii, it is usual to begin the rise of the outer rail at a distance of from 50 to 100 feet back on the straight line, for each inch of elevation. Thus, for 6 inches elevation, some engineers go back 600 feet, and others but 300, and rise gradually until the entire elevation is attained by the time they reach the P C, or beginning of the curve.

But if easement curves are used at the ends of the main one, the elevation is begun at the beginning of the easement.

The writer believes that even 50 feet per inch of elevation is more than is necessary. In his suggestion, p. 90, for using easement curves 150 feet long in all cases, if the elevation begins with the easement, it will (for a speed of 60 miles per hour) vary between 2.37 inches in 150 feet on a 1° curve (5730 ft. rad.); and 6 inches in 150 feet on all curves of $2\frac{1}{2}$ ° or more, supposing 6 inches to

be the limit. This last is equal to 1 inch in 25 feet, or to a grade of 17.6 feet per mile, which the writer cannot regard as excessive, especially when the grades are reduced for curvature.

In the Wharton Safety Switch, as it has been laid for many years on a number of our main lines, there is an elevation of $2\frac{1}{2}$ ins. in a distance of only 4 feet; or at the rate of 15.6 ins. in 25 feet; or 275 feet per mile. This sudden rise has since been reduced to $1\frac{3}{4}$ ins., or still nearly 11 times our maximum rate.

Should ours, however, be considered too rapid a rise, the elevation may be commenced 50 or more feet farther back on the tangents of such curves as require more than say about 4 inches elevation; and without any change in the easement curvature itself. But, as before remarked, the writer does not himself consider this at all necessary; the main point being, in his opinion, to enter the easement curve without jar; and then to maintain a gradually increasing outward pressure (insensible to passengers) until the main curve is reached. He believes that by the foregoing method these desiderata will be secured, at least so far as practical considerations may call for.

TABLE OF ELEVATION OF OUTER RAIL IN CURVES; FOR GAUGE 4 FT. 81 INS.

| 400 | 350 | 300 | 250 | 200 | 180 | 160 | 140 | 120 | 100 | 90 | 80 | 70 | 60 | 50 | 40 | 30 | 28 | 10 | 1 | Angle of Deflecti | | | | | n. |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|--------|-------------------|-------------|-------|---------|-------|------------|
| 146 | 166 | 193 | 231 | 288 | 320 | 359 | 410 | 478 | 574 | 637 | 717 | 819 | 955 | 1146 | 1433 | 1910 | 2865 | 5730 | | Ra | diu | s in | Fe | et. | |
| -65 | .57 | .49 | .41 | 333 | -30 | -26 | 293 | -20 | .17 | .15 | -13 | -12 | .10 | 80. | .07 | -05 | .03 | .02 | | 53.8 | | 7.33 | 1 | 5 | |
| 2.59 | 2.27 | 1.96 | 1.63 | 1.31 | 1.18 | 1.05 | .92 | .79 | -66 | .59 | .53 | -46 | .40 | 333 | -26 | -20 | .13 | .07 | | 215 | | 14.7 | | 10 | |
| 5.82 | 5.12 | 4.40 | 3.68 | 2.95 | 2.65 | 2.37 | 2.07 | 1.78 | 1.48 | 1.33 | 1.19 | 1.04 | .89 | .74 | .59 | .45 | -30 | .15 | | 484 | SOI | 22.0 | | 15 | |
| 10.3 | 9.10 | 7.82 | 6.54 | 5.24 | 4.72 | 4.21 | 3.68 | 3.16 | 2.63 | 2.37 | 2.11 | 1.84 | 1.58 | 1.32 | 1.05 | .79 | .53 | -26 | ELEVAT | 860 | TARE OF | 29.3 | VELOC | 20 | AREA |
| 23.3 | 20.5 | 17.6 | 14.7 | 11.8 | 10.6 | 9.46 | 8.29 | 7.11 | 5.93 | 5.84 | 4.74 | 4.15 | 3.56 | 2.46 | 2.37 | 1.78 | 1.19 | .59 | ION OF | 1936 | P VELO | 44.0 | ALL | 30 | OCALL ! |
| 42.2 | 36.9 | 31.6 | 26.3 | 21.0 | 18.9 | 16.8 | 14.7 | 12.6 | 10.5 | 9.49 | 8.43 | 7.38 | 6.32 | 5.27 | 4.22 | 3.16 | 2.11 | 1.05 | OUTER | 3442 | VELOCITY IN | 58.7 | IN FEET | 40 | DE DESERVE |
| | | | • | | | | 23.0 | 19.8 | 16.5 | 14.8 | 13.8 | 11.5 | 9.88 | 8.23 | 6.59 | 4.94 | 3.29 | 1.65 | RAIL 1 | | Telefal a | 73.3 | PER S | 50 | A R. R. S. |
| | | | | | | | | | 23.7 | 21.3 | 19.0 | 16.6 | 14.2 | 11.9 | 9.48 | 7.11 | 4.74 | 2.37 | N INCH | 7744 | PER SECOND | 88.0 | SECOND. | 60 | MANUEL. |
| 7 | | | | | | | | | | | | 22.6 | 19.4 | 16.1 | 12.9 | 9.68 | 6.45 | 3.23 | ES. | 10540 | COND. | 103 | | 70 | |
| | | | | | | | | | | | | | | 21.1 | 16.9 | 12.6 | 8.43 | 4.22 | | 13766 | | 117 | | 80 | |
| - | | | | | | | Ī | | | | | | | 7 | 26.3 | 19.8 | 18.2 | 6.59 | | 21510 | | 1 147 | | 1 100 | |

ARTICLE XLI.

Equation of Curvature.

This consists in ascertaining what amount of *straight distance* produces an expenditure of motive power equal to that produced by a given amount of curvature, say 1°.

There is a certain amount of resistance encountered by trains on a straight line; and the overcoming of this resistance costs money, not only for motive power, but for repairs of engines, cars, tracks, bridges, etc. But if that identical piece of straight road be bent into a curve, without any alteration in its length, then the resistance and the consequent expense of motive power and repairs will also be increased; and it is usually supposed that the increase will be in proportion to the amount of bending. This increase, therefore, is plainly not a consequence of the distance, which remains as before, but merely of the bending, deflection, or curvature; and in equating for curvature, with a view to a comparison with straight lines, we have to consider, not the total resistance upon the curve, but only that portion of it which is due to the curvature. If we knew, from experiment and observation, how much the expenses of running a road are affected by curvature. we might prepare formulas giving a tolerably accurate solution of the question; but in the absence of such data, we are compelled to resort to certain assumptions, the correctness of which is somewhat problematical. It is probable, also, that facts which should materially modify our conclusions are lost sight of; as, for example, the greater danger of sudden curves.

It is assumed that the total amount of extra power due to curvature, and expended in running around any given curve, at any given speed, is in proportion to the number of degrees contained in the curve, without regard to its

radius or length.

Thus, 1° of radius of 400 feet has only ½ the length of 1° of 1600 feet radius; but the extra power exerted at any one instant, on the short radius, must be 4 times as great as that on the long radius, in order to keep up the same speed on both. But on the long radius, although the power exerted at any one instant is only ½ as great as that

on the short one, still it has to be exerted 4 times as long, or during 4 times as many instants, while carrying the train at the same rate of speed through its 4-times-as-long 1°. Therefore, the total expenditure of *extra* power in running around 1° of curve is the same in both cases.

Now, we have already said that on a level straight line, in perfect order, and with the machinery in ordinary use. the resistance to a train moving at 25 miles an hour may be taken as approximately equal to 12 lbs. per ton of the entire weight of the train. We have also assumed that a curve with 1° of deflection angle increases this resistance to the extent of 1.05 lbs.; and that with other angles of deflection, the *increase* of resistance will be in proportion to the number of degrees contained in them; so that a curve of 11% deflection angle will present an increase of continuous resistance equal to the whole of that on the straight line. In other words, the total resistance exerted at each instant on the curve will be twice that exerted on the straight line at the same speed. Hence, if on any proposed lines of survey we have a mile of 111° curvature. upon which the velocity is to be 25 miles per hour, that mile will require as much power as 2 miles of straight line. But a curve of 1110 deflection angle has a radius of 500 feet, and a circumference of 3141 feet, which latter is of course equal to 360° of the curve. And if 3141 feet are equal to 360°; a mile, or 5280 feet, is equal to 605°. Hence, 605° of curve of 111° deflection angle requires a total expenditure of power equal to that required on 2 miles of straight line; in other words, the curvature alone requires an increase of power equal to the total power required on a mile of straight line. Therefore, if this mile, or 605° of 111° curve, could be straightened into a mile of direct line, we should forever afterwards save the expense of half the power required to run it; that is, we should save power enough to run one mile of straight line. But we have before assumed that the power expended upon curves is in proportion to the number of degrees contained in the entire curve, without any regard to the radius, or to the length of the curve. If this be the case, it follows that, by merely straightening 605° of any curve, we shall, without diminishing its length, save power enough to run 1 mile, or 5280 feet of straight line; or by straightening 1° we shall save power sufficient for $\frac{5280 \text{ feet}}{605^{\circ}} = 8.7$

feet of straight line; and with this power, we should also save the wear and tear of machinery and track, etc., which it produces, and which are assumed to be about in pro-

portion to the power expended.

But the important point is to reduce this saying of power and repairs to a moneyed value. This will vary with the annual expense of running the road. The process usually adopted for this purpose is as follows: Experience shows that of all the annual expenses of running a railroad, those which may be assumed to be pretty nearly in proportion to the power expended, such as wear and repairs of engines, cars, track, etc., etc., compose, as an average of many roads, about two-thirds. Therefore, if we judge from previous calculations that the annual receipts on our proposed railroad will be about \$4500 per mile; and the expenses about \$3000, or two-thirds of the receipts, which is the approximate average of most railroads; then about \$2000 per mile, or 38 cents per foot of road, will generally be nearly in proportion to the motive power expended. But we have seen that 1° of curvature, or deflection, incurs as much annual expense for motive power as 8.7 feet of straight line; or, in this case, 38 cts. \times 8.7 = \$3.30. Now, 38 cents is the interest at 6 per cent, on \$6.33; and \$3.30 is the interest on \$55; therefore, in this instance, according to the foregoing, and with a speed of 25 miles per hour, we should be warranted in expending \$6.33 to shorten the length of the road one foot; or \$55 to merely straighten 1° of curvature.

Having arrived thus far, we are enabled to decide, to some extent, upon the comparative merits of two or more surveyed routes for our road; that is, we can equate them for curvature. Thus, suppose that one of the surveys is 100 miles long, and has 3025° of curvature; while the other is but 98 miles long, but has 4840° of curvature. Now, since the annual expenses of 605° of curvature are equal to those on a mile of straight line, we have for the two lines as follows:

Miles of distance.

Miles equated for curvature.

Miles as regards annual expenses of running the road.

1st line.
$$100 + \left(\frac{3025^{\circ}}{605^{\circ}} = \right)$$
 5 = 105

2d line. $98 + \left(\frac{4840^{\circ}}{605^{\circ}} = \right)$ 8 = 106

Therefore, as regards annual expenses, the longest line will be the cheapest by nearly 1 per cent., so far as curvature is concerned. This may, however, be neutralized by superiority of grades on the shorter line; or by other

causes not of an engineering character.

This, we believe, is about the view usually taken of this subject. Engineers, however, generally assume the resistance of curves at much less than our estimation of it, and consequently give a shorter straight distance as equivalent to 1° of curvature. Although we regard the whole process as empirical, it at least serves to caution us against too hastily introducing curves, from a mistaken idea of economy in the first outlay. On the Pennsylvania R. R., at the time of its location, the saving of 1 foot of distance was valued at \$10, or \$52800 per mile; and the saving of 1° of curvature at \$50, or \$18000 for a complete circle; thus making 1056°, or nearly three complete circles to be equivalent to 1 mile of distance. With the present enormous business of that road the foregoing valuations of curvature and distance would be absurdly small. Competition is a powerful element in such matters.

Finally, inasmuch as the foregoing is merely a crude, incomplete, and superficial treatment of this difficult subject, we again refer those who wish to study it in the light of the most recent experience and investigation, to the standard "Economic Theory of the Location of Rail-

ways," by Arthur M. Wellington, C. E.

TABLE OF MIDDLE ORDINATES,

To be used for the bending of rails of different lengths, so as to form portions of curves of different radii. radii intermediate of those in the table, may be found by simple proportion.

t radii. Ordinates for lengths or

| | | | | LENG | LENGTHS OF | KAILS. | | 1 | | | |
|-------------|---|-------|-------|-------|------------|--------|-------|-------|-------|-------|------------------|
| 28 26 | | 24 | 22 | 90 | 18 | 16 | 14 | 122 | 10 | 00 | 9 |
| Feet. Feet. | | Feet. | Feet. | Feet. | Feet | Feet. | Feet. | Feet. | Feet. | Feet. | Feet. |
| | | 1.005 | -004 | .004 | -003 | -005 | -005 | -001 | -001 | 000- | 000- |
| •016 •013 | | -011 | 600. | 800. | 900. | ·000 | .004 | ·003 | -005 | .001 | -001 |
| - | | -018 | .016 | .013 | .010 | 800. | 900. | ·004 | .003 | -005 | .001 |
| | | .025 | .021 | -017 | ·014 | .011 | 800. | 900. | ·004 | .003 | -001 |
| | | -031 | .027 | .022 | .018 | •014 | .010 | -000 | -009 | .003 | -005 |
| | | -087 | .031 | .026 | .055 | -017 | -012 | 600- | 900. | ·004 | -005 |
| - | | .048 | .087 | .031 | -025 | .050 | -015 | -011 | 800· | 900- | •003 |
| | | -090 | .042 | .035 | .029 | .023 | •018 | .018 | 600. | 900. | .003 |
| | | -056 | .047 | •089 | .032 | -026 | .050 | 010 | 010- | 200. | -004 |
| | | -063 | .053 | .044 | -085 | •050 | .055 | 010 | .011 | 200. | -00 - |
| | | 020- | .059 | .048 | -039 | .032 | .024 | .018 | .012 | 800. | -004 |
| | | 920- | .064 | .052 | .042 | .034 | .026 | -019 | .013 | 800- | -002 |
| | | -085 | 690. | .057 | .046 | .087 | .028 | .021 | ·014 | 600- | -009 |
| | _ | 880. | ·074 | .061 | .049 | .089 | .030 | .055 | -016 | 010 | -009 |
| | _ | €00 | 620- | -065 | .053 | .042 | ,082 | .024 | .016 | 010 | 900. |
| _ | | .100 | .085 | 070- | 990- | .045 | .034 | .025 | -017 | .011 | 900. |
| _ | | •106 | 060. | ·074 | 090- | •048 | .086 | -027 | .018 | .012 | 200. |
| _ | _ | .112 | -095 | ·078 | -063 | 090. | .088 | .029 | .019 | .012 | -000 |
| _ | | .119 | 101 | •083 | 190. | ·054 | .042 | .031 | .021 | +013 | 800- |

TABLE OF MIDDLE ORDINATES-CONTINUED.

| | | | | | | | LENG | LENGTHS OF RAILS | RAILS. | | | | | |
|--------|--------|-------|-------|-------|-------|-------|-------|------------------|--------|-------|-------|-------|-------|-------|
| of ano | Radina | 30 | 28 | 26 | 54 | 22 | 30 | 118 | 16 | 14 | 12 | 10 | 00 | 9 |
| Deg. | Feet. | Feet. | Feet. | Feet. | Feet. | Feet. | Feet. | Feet. | Feet. | Feet. | Peet. | Feet. | Feet. | Feet. |
| | 578-7 | .196 | .171 | .148 | .125 | .106 | -087 | .071 | -057 | -045 | -032 | -025 | -014 | 00. |
| 11 | 521.7 | -216 | .188 | .163 | -189 | .117 | 960. | 810. | .063 | .049 | •086 | .024 | •016 | 600- |
| - | 478.3 | .236 | .206 | .179 | .151 | .128 | .105 | •085 | 690. | .053 | -086 | .026 | .017 | -01 |
| - | 441.7 | -254 | .222 | .192 | .163 | •138 | ·113 | -095 | .075 | -057 | .045 | .028 | .019 | -01 |
| - | 410.8 | -275 | -239 | -207 | .175 | .148 | .122 | 660. | 080 | -061 | .045 | .030 | -050 | .01 |
| | 883-1 | -295 | -257 | .228 | .188 | .159 | .181 | .106 | 980. | -065 | -049 | .088 | .021 | .01 |
| | 859-8 | .313 | .278 | .286 | .200 | .170 | .139 | .118 | -091 | 020- | .052 | .035 | .023 | -01 |
| | 338.3 | .333 | -290 | .252 | .213 | .180 | .148 | .120 | 960- | .074 | .055 | .087 | .024 | .01 |
| 3 | 819.6 | .351 | -306 | -265 | -225 | .190 | 156 | .127 | .102 | .078 | .058 | •080 | .025 | .01 |
| - | 802.9 | .871 | .824 | .280 | .238 | .201 | .165 | .134 | .108 | -085 | .061 | .041 | -027 | -01 |
| - | 287.9 | .892 | .841 | .296 | -250 | -212 | .174 | -141 | 114 | .087 | 990- | .044 | .028 | .01 |
| | 274.4 | -410 | .857 | .309 | -262 | .222 | .182 | .148 | .120 | .091 | 690- | .046 | -080 | .01 |
| ~ | 262. | .480 | -875 | .325 | -275 | .233 | .191 | .155 | .126 | 960. | -072 | .048 | ·081 | .01 |
| ~ | 250.8 | .450 | -390 | .338 | -287 | .243 | .199 | -162 | .181 | .100 | .075 | .050 | .033 | .01 |
| | 240.5 | .469 | -408 | .854 | .299 | .258 | .208 | -169 | -187 | 104 | .078 | .052 | .034 | .018 |
| | 231 | .486 | -424 | .867 | -811 | .263 | .216 | •176 | .142 | •108 | .081 | ·054 | •035 | .020 |
| 3 | 222.8 | 909- | -441 | -382 | -828 | -274 | .225 | .183 | .148 | .112 | ∙084 | .056 | -087 | .021 |
| - | 214.2 | .524 | -457 | .896 | .835 | -284 | .283 | .190 | .153 | .116 | -087 | -058 | .088 | -022 |
| 3 | 206-7 | -545 | .475 | .411 | .848 | .294 | -242 | 197 | .158 | .120 | 060- | 090- | -039 | .052 |
| | 199-7 | -564 | .491 | -424 | .861 | .303 | .250 | .208 | .163 | -124 | •093 | -062 | .041 | .028 |

ARTICLE XLIII.

The Engineer's Transit.

The following description is longer than desirable; but it would have been much more so if we had not assumed that the reader has an actual transit before him, and can thus see at a glance many points which it would be tedious to describe in writing, and which we therefore omit.

The details of the Transit are differently arranged by different makers, and to suit special purposes. Still its essential parts so nearly resemble each other in all, that they may be understood from our Figs. 53\(\frac{1}{4}\) and 53\(\frac{1}{2}\), which represent it in its modern form, as made by Heller & Brightly, of Philadelphia.* This widely known firm frequently modify the details of their instruments to meet the requirements of purchasers; so that in some cases they do not correspond exactly to the following description, or to our figs. We will specify some of the variations as we proceed. The letters on the two figs. correspond. Some letters are repeated for different parts, but not where they could lead to error.

The long bubble-tube, F F, Fig. 53½, under the telescope; and the vertical graduated arc g, are furnished only when the instrument is to be used for levelling or for measuring vertical angles. Without these appendages the instrument is their Plain Transit. With them, or rather with a graduated full circle instead of a mere arc, it becomes virtually a Complete Theodolite, vastly preferable to the clumsy and heavy instruments occasionally imported from Europe under that name.

Beginning at the wooden legs, their heads, Q, Fig. 53½, are attached (by means of bolts with wing heads) to lugs, D, cast in one with a stout circular piece, B, Fig. 53¼, called the **Tripod Head**, which screws up into the **lower parallel plate**, S. The screw-threads at v receive the screw of a wooden tripod head cover when the instrument is out of use.

Referring now to Fig. 531, in the center of the lower

^{*}The price of a first-class plain transit, with shifting-plate and plumb-bob, by these makers, is \$185. One with vertical arc, g, and long bubble-tube, FF, \$220.

parallel plate, SS, is seen a large circular opening, in which plays a casting, ccdd, the upper part, dd, of which, forms a socket enclosing the half ball, b; while its lower pari, cc, below S, constitutes the shifting plate. The object of this shifting plate, and of the large opening, is, after the transit is set very nearly over the center of a stake, to allow it to be placed exactly over it, by shifting all the upper parts of the instrument a trifle, without moving the legs; thus saving time. To permit this shifting, the levelling screws, K, must first be a little loosened, but after the shifting they are tightened again, by which process they push upwards the upper parallel plate, m, thereby drawing upward the half ball, b, which in turn draws up the shifting plate, e, firmly against the lower side of S, and keeps it there.

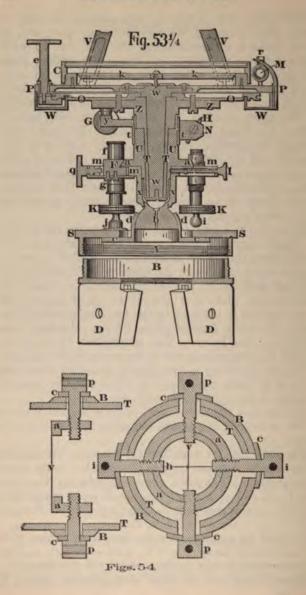
Above the half ball, b, and screwed to the top of it, is the single casting, mmmxx, the upper part, mmm, of which, forms the **upper parallel plate**; while the part xx forms a socket into which the spindles, U, T, and w, foot. **The half ball**, by its play in its socket, dd, allows the upper parallel plate, mm (and all the upper parts of the instrument), to be set level by the levelling screws, K, although the *lower* parallel plate, SS (as constantly happens), may not be so. The **plumb-bob** string passes through the vertical hole seen in the center of the half ball.

The four levelling screws, K, are protected from rain and dust by screw caps, f and g, which may be removed as shown at the right-hand screw, K.

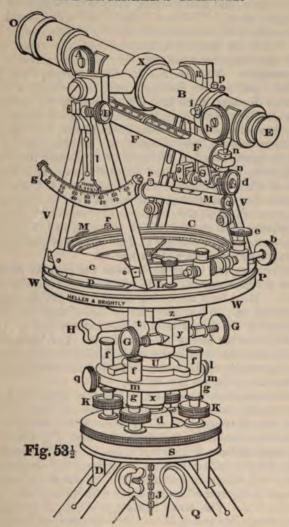
The feet, i, of the screws, work in loose sockets, j, which are flat at bottom, to preserve the plate, S, from being indented.

The parts thus far described are generally left attached to the wooden legs, not only in the field, but in the house between work. The parts above m (including the spindles, U, T, and w, and all the upper parts, which they support), may at any time be lifted together off from, or replaced upon, the parts below, thus:

To place the upper parts upon the parallel plates, place the lower end of the spindle, U U, in the socket, xx, holding the instrument so that the three recesses in the flange, a a, shall pass down over the three corresponding blocks, F,



THE ENGINEER'S TRANSIT.



on the upper side of m; thus allowing the flange to bear fully upon m, and thus to bring upon m the weight of all the upper parts. The inner end of the spring-catch, l, in the meantime, automatically enters a groove around U, just below the flange a a, thus securing the upper and lower parts together when the instrument is carried over the shoulder. Now see that the clamp screws, e and H, are fast; and revolve the upper parts horizontally a trifle in either direction until they are stopped by the striking of the small lug on a a, against one of the fixed blocks, F. The recesses in a a are now clear of the blocks, F. Tighten the clamp screw q, thus pressing the beveled edge of F tight up against that of the flange, a a, thereby fastening the spindle, UU, to the fixed parallel plates. It is to remain so while the instrument is being used; U U and all below it then constituting, as it were, a fixed or stationary base, upon which all above it is free to revolve by means of the spindles, TT and ww, which may turn in UU, either singly or together, according as their respective clamps are loose or tight, as explained further on.

To remove the upper parts from the parallel plates, loosen the clamp-screw, q. Bring the recesses opposite the blocks. Hold back the spring catch, l, and lift the upper parts from m. When they are so lifted, they are held together by the broad head of the screw which is seen inserted into the foot of the spindle, w. This spindle is shown solid, but it is really made hollow in order to reduce the weight of the instrument; and the screw spoken

of fits into a plug let into its foot.

Some engineers remove and replace the upper parts of their transit whenever they move it from one stake to the next; but others carry it, all in one, over the shoulder.

We come now to the Revolving Spindles, T T and w w. The Outer Spindle, T T, is cast in one with the Supporting Plate, Z Z; so called because it supports the Graduated Limb, O O, which is fastened to it by screws (of which two are seen), and of course turns with it, and with the spindle, T T. The Inner Spindle, w w, has, at its top, a broad flange, by means of which it is fastened by small screws (two of which are seen) to the Vernier Plate, P P. The vernier plate necessarily revolves with this inner

spindle, and carries with it all the parts above it, as the Compass-Box, C; the standards, V V; the telescope, etc.

To confine the Graduated Limb, O O, to the fixed spindle, U, tighten the clamp-screw, H. This presses the split collar, tt, tightly against the fixed spindle, U (but not against Z or T). The tongue, y, which projects from the collar, is held between the points of two set-screws, of which one, G, is shown, and which move in nuts that are cast in one piece with the supporting plate, ZZ. The latter is thus prevented from revolving when H is clamped, except by the slow-motion, which may still be given to it, and to its graduated limb, by means of the set-screws, G.

To confine the Vernier Plate, PP, the telescope, etc., to prevent them from revolving over the graduated limb, OO, tighten the clamp-screw, e. This binds together the two small pieces at its foot, confining between them an edge of the graduated limb. The lower one of these pieces is fastened to one of the two towers, in which works the tangent-screw, b, Fig. $53\frac{1}{2}$. The other tower is fixed to the vernier plate. By this tangent-screw we may slightly change the distance apart of the two towers, and thus a slow-motion over the graduated limb can be given to the

vernier plate after e is clamped tight.

Reviewing briefly, when the transit is in use, the clamp, q, always remains fast, and the spindle, U, fixed. By clamping H we prevent ZZ and OO from revolving (except very slightly by means of the set-screws, G). By now clamping e we prevent w w, PP, the telescope, etc., from revolving horizontally (except slightly by means of the tangent-screw, b, Fig. $53\frac{1}{2}$), and the entire instrument is clamped fast. Loosening e (H remaining clamped), we release the vernier plate, PP, and allow it, with the telescope, etc., to revolve freely over the still stationary graduated limb, OO. Again, clamping e and loosening H, we have TT, ZZ, OO, w w, PP, the telescope, etc., free to revolve, as a whole, in the fixed spindle, U.

W W is a Dust-box surrounding the vernier plate, and

protecting it and the graduated limb.

C is the Compass-box, which is screwed fast to the vernier plate, PP; and kk is the Needle; just above which is seen the glass cover of the compass-box.

H

10*

M, Fig. 531, is a cross-section of one of the two short **bubble-tubes**; and r is one of its capstan-headed adjusting-To their right is seen a curved piece of brass for protecting the bubble-glass. The positions of these two tubes are shown at M M, Fig. 531.

V V are the standards supporting the telescope.

At p, Fig. 531, is one of the two Verniers with which the vernier plate is furnished. Both may be read, and their mean taken, when great accuracy is required. Ivory

reflectors, c, facilitate their reading.

Before the instrument is moved from one station to another, the needle should always be pressed up against the glass cover by means of the milled-head upright screw seen on the vernier plate, just to the right of the nearest standard. Its pivot-point is thus protected from injury.

The Telescope, E O, is usually from 9 to 12 inches long. It is sometimes made to show objects inverted;

but more generally upright.

At R, Fig. 531, is a ring with a clamp (the latter not shown) for holding the telescope in any required position. One end, R, of the axis of the telescope rests in a movable box at the top of the standard. This box may be raised or lowered by means of a screw placed underneath it, and the axis thus adjusted for very slight derangements of the standards. The tangent-screw, whose head, d, is seen just below n n, moves a vertical arm attached to the clamp-ring at R, and is used for slightly changing the elevation of the telescope in measuring vertical angles, or when using the instrument as a level.

In the vertical arm is a slit, similar to the one seen in the vernier-arm, l, of the graduated vertical arc, q. When zero of this vernier is placed exactly at 30° on the arc, and the opposite arm placed exactly opposite a small notch on the horizontal brace (not seen in our figs.) of the standard, the two slits will be exactly opposite each other, and may thus be used for laying off offsets, etc., at right angles to the line of sight.

The slide of the object-glass, O, Fig. 531, is moved backward or forward by a rack and pinion, by means of

the milled head, A.

The slide of the eye-glass, E, is sometimes moved in

the same way by a milled head, h_j but often the eye-piece is threaded, and in that case is moved in or out by simply turning it.

The object-slide is protected by a dust-and-rain-guard, a. A short brass tube, called a shade, is usually furnished with each transit. It is intended to be slid on to the object-end, O, of the telescope, to prevent the glare of the

sun upon the object-glass when the sun is low.

The Cross-Hairs.—At B, Fig. 531, is an outer strengthening ring, see also Figs. 54, carrying four small capstanscrews, pp, ii. These screws work in the cross-hair ring, a, Figs. 54, which has, stretched across it, two spider-webs, v and h, usually called the cross-hairs. These are much finer than they appear to be, as they are considerably magnified by the eve-glass. The small holes around the heads of the 4 small capstan-screws, pp, ii, are for admitting the end of a small steel pin, or lever, for turning them. If first the upper screw be loosened, and then the lower one tightened, the interior ring will be lowered, and the cross-hairs with it; and vice versa. The screws, ii, at the sides act in the same way for moving the ring sideways. If the telescope is an inverting one, that is, if it makes objects appear inverted, the cross-hairs will appear through the eye-glass to travel in the direction in which they actually move: but when the telescope, as is usual, shows objects erect, then the cross-hairs will appear to move in the direction opposite to their actual motion, as given by the screws. There is no danger of injuring the hairs by turning the capstan-screws, inasmuch as the screws act upon the ring only; and, as seen in Figs. 54, do not come in contact with the hairs themselves.

ARTICLE XLIV.

To Adjust a Transit.

When either a level or a transit is purchased it is a good precaution to first screw the object-glass firmly home to its place; and then make a short, continuous scratch upon the ring of the glass, and upon the head of its slide, so as to be sure at any time when at work that the glass is in the same position, with regard to the slide. For if, after

all the adjustments are completed, the position of the glass should become changed (as it is apt to be if unscrewed, and afterward not screwed up to the same precise spot), the adjustments may thereby become materially deranged if the object-glass is eccentric or not truly ground. Such

scratches should be prepared by the maker.

Before making adjustments, as well as while using a transit or level, the eve-glass and object-glass must be so drawn out that there shall be no parallax; that is, so that the cross-hairs shall not appear to dance about if the eye is moved a little up or down or sideways. To secure this, take sight at some object, and move the object-glass and eve-glass until the object and the cross-hairs are both seen distinctly; the latter without any of the apparent motion alluded to. After that, the eye-glass must be let alone; and only the object-glass be moved for obtaining distinct vision at different distances.

Make the Adjustments in the Following Order.

Ist. To adjust the two short bubble tubes M M. Fig. 531. By means of the four levelling screws, K, bring the two bubbles to the middles of their tubes. Then turn the upper parts of the instrument half way around. If the bubbles do not remain in place, correct one-half of the error by means of the small capstan-headed screws, r. of which there are two at one end of each tube; and the other half by the four levelling screws. This operation must be repeated until the bubbles remain at the middles of their tubes while the instrument is being turned entirely around.

2d. See whether the vertical hair is placed truly so in the telescope. To do this, first level up; then take sight at a plumb line, or other vertical object. If the two coincide, the hair is right. But if not, loosen slightly only two adjacent screws, of the four ppii, Fig. 54, and with a penknife, key, or other light instrument, tap very gently against the sides of the screw heads, until the hair coincides with the plumb line, etc., and then tighten the screws.

Two or three trials may be necessary.

As to the horizontal hair, its exact position is not important: but it is best to have it near or at the center of

the vertical one; and if the instrument is to be used for levelling, or for taking angles of elevation or depression from the horizontal, take care that it is not moved after the adjustments are finished.

3d. To see whether the vertical hair travels vertically

while the telescope is being moved up and down.

First, level up; then take sight at some high object, such as the top of a church steeple near by. Clamp, and lower the telescope so as to sight on some low object. If there is no other, drive a stake, or chain-pin, etc., in the line. Unclamp, and revolve the upper parts of the instrument half way around. Clamp, and sight again at the high point. Lower the telescope again to the low point. If the hair still strikes this last it is in order. If not, the standards VV have been deranged, and the instrument must be sent to the maker to be rectified, unless it be provided with an adjusting block and screw under one end of the axis of the telescope, by means of which slight derangement of standards may be counteracted. quarter of the error must then be corrected by this; and the trial be repeated de novo; resetting the stake or chainpin at each trial.

4th. To adjust the line of collimation, so that the vertical hair shall strike objects in the same straight line on both sides of the instrument, when the telescope is revolved vertically for taking both back and foresights.

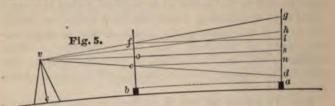
Placing the instrument firmly at a, Fig. 55, level up, and take sight at any convenient object, b, as a chain-pin, stake, etc., distant 100 feet or more. Clamp, and revolving the telescope vertically, observe some other object, as c, where the vertical hair then strikes; or better, drive a chain-Fig. 55 pin, c, in the line. It is not necessary that the distances ab, ac, be equal; the longer they are the better. Unclamp, and turn the upper parts of the instrument half around horizontally, until the vertical hair again strikes b. Clamp, and again revolve the telescope vertically. If the hair now strikes c, this adjustment is in order, and c is really at o. But if it does not, observe where it does strike, say at m, and place a pin

there also. Measure mc, and at one-fourth of it, as at v, place another pin. Then by the two horizontal screws, ii, Fig. 54, move the vertical hair until it strikes v, remembering that the hair must be moved in the opposite direction from what appears to be the right one, unless the telescope is an inverting one, which is now rarely the case.

The trials must be repeated until the adjustment is perfect.

The foregoing are all the adjustments needed, unless the transit is required for levelling, in which case the following one must be attended to.

5th. To adjust the long bubble tube, FF, Fig. 53½, beneath the telescope, so that when level, it shall be parallel with the line of sight, or of collimation.



of the two small nuts n n at one end of the tube, Fig. $53\frac{1}{2}$, and assume that the telescope and tube are parallel.*

Remark. If no level is at hand, the two stakes, ab, Fig. 56, or mn, Fig. 57, may be set level by the transit itself, thus: Level the instrument by the 4 levelling screws. Drive one of the stakes, say m, at a distance of 100 to 300 feet from the instrument, o. Place a target-rod on m, and clamp the target tight at any convenient height whatever, as ev, at which the horizontal hair may be made to strike it; it being of no importance whether the telescope is level or not. Clamp the telescope by the clamp at R, Fig. $53\frac{1}{2}$, so that it cannot revolve vertically. Then revolve the instrument horizontally a considerable way around; it may be nearly or

around; it may be nearly or quite half way; and drive vo another stake n, at precisely the same distance from o that

en Fig. 57

m is; and continue to drive it until the horizontal hair again cuts the target placed on top of it, and still clamped at the same height as when on m.

The tops of the stakes are then on the same level, and ready for the preceding 5th adjustment.

To Replace Broken Cross-Hairs.

These so-called hairs are, in fact, very fine cobweb; fine

human hair is entirely too coarse.

Take out the tube from the eye end of the telescope; and looking in, notice which side of the cross-hair diaphragm, a a, Fig. 54, is turned toward the eye. Then loosen the four screws, p p, i i, Fig. 54, which hold the diaphragm, so as to let the latter fall out of the telescope. Fasten on new hairs with beeswax, varnish, or

^{*}This neglects a small error due to the curvature of the earth; for a horizontal line at v is v h, tangential to the curved (or "level") surface of still water at v, whereas v s is tangential to water surface at a point midway between a and b. Hence if the telescope at v points to s it will not be parallel to the level bubble-tube. To allow for this, and for the refraction by the air, which diminishes the error, raise the target on a to a point h above s. h s=.0000000205 \times square of a c in feet; but when a c is 650 feet, h s is only about one-tenth of an inch and barely covers the apparent thickness of the cross-hair in the telescope.

gum-arabic water, etc. This requires care. Then, to return the diaphragm to its place, press firmly into one of the screw-holes on its circumference the end of a stick, long enough to reach to where the diaphragm belongs. By this stick, as a handle, insert the diaphragm edgewise into its place; and hold it there until two opposite screws are put in place and screwed. Then draw the stick out of the hole in the diaphragm; and with it turn the diaphragm until the same side presents itself to the eye as before; then put in the other two screws.

To Replace a Broken Bubble-Glass.

Detach the bubble tube from the instrument; draw off its sliding ends; push out the broken glass, and the cement which held it. Insert the new glass, with the proper side up (this side is always marked by the maker with a file-mark), wrapping some paper around its ends if it fits loosely. Finally, put a little putty, or melted beeswax, over the ends of the vial, to secure it against moving in its tube.

In purchasing instruments, especially when they are to be used far from a maker, it is advisable to **provide extras** of such parts as may be easily broken or lost; such as glass compass-covers, compass-needles, adjusting-pins,

bubble-glasses, magnifiers, etc.

The following is a good form of field-book for the transit and compass combined.

| Station. | Distance. | Total Distance. | Course. | in Degrees. | The right hand page is left blank for Re- marks, and Sketches of Topography. |
|----------|-----------|--------------------|---------|-------------|---|
|----------|-----------|--------------------|---------|-------------|---|

ARTICLE XLV.

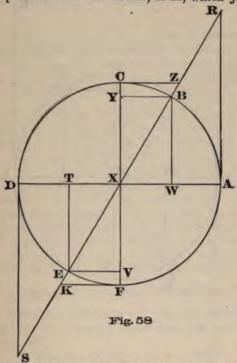
Sines, Tangents, Etc.

The Complement of an angle or arc is its difference from 90°. Thus, in Fig. 58, the arc, AB, of 60°, is the complement of BC, which is 30°; and BC is the complement of AB. In like manner, BC is the complement of BCD; BCD that of BCDF; and BCDF that of BCDFA.

The Supplement of an angle or arc is its difference from 180°. Thus AB and BCD are supplements to each

other: so also A B is the supplement of A B C D E; and B C D is that of B C D F A.

The Sine of an angle or arc is a straight line, BW, drawn from either extremity, as B, of the angle or arc, AB, perpendicular to the radius, AX, which joins the



other extremity, A, of the arc, and the center, X, of the circle.

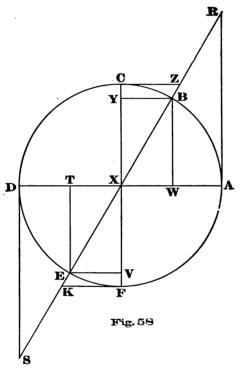
The Tangent is a straight line, R A, touching one extremity, A, of the arc, A B, and limited between that point and its intersection, R, with a secant, X R, which passes through the other extremity, B, of the arc.

The Secant is a straight line, X R, drawn from the center, X, of a circle, through one extremity, B, of an arc, A B, to meet the farther extremity, R, of a tangent, R A, which touches the other extremity, A, of the arc.

For Versed Sines, see page 169.

The Cosine of an angle or arc is the Sine of the Complement of the arc.

The Cotangent is the Tangent of the Complement. The Cosecant is the Secant of the Complement.



The Sine, Tangent, Secant, Cosine, Cotangent, and Cosecant of an arc, are respectively = the Sine, Tangent, Secant, Cosine, Cotangent, and Cosecant of the supplement of the arc; but the versed sine of an arc is not = the versed sine of the supplement of that arc. See page 169.

Thus, in Fig. 58,

B W (= T E) is the Sine of arcs $\stackrel{600}{A}$ B, $\stackrel{1200}{C}$ D, $\stackrel{2400}{A}$ B C D E, B C D E F A.

A R (= DS) is the Tangent of the same arcs.

X R (= X S) is the Secant of the same arcs. X W (= X T) is the Cosine """" C Z (= F K) is the Cotangent"""" X Z (= X K) is the Cosecant""""

Natural Sines, etc., are those for a circle whose radius is 1.

On p. 124 will be found a Table of Natural Sines, Tangents, Cosines, and Cotangents, for all arcs from 0° to 90°; and, on p. 123, directions for extending them to all other angles up to 360°; also for finding the secants and cosecants of all angles from 0° to 360°.

Remark.—When, as in Art. XXXIV., an angle is to be found from the table by means of its sine, etc., it is important to bear in mind that each sine, etc., in the table, is sine, etc., to four different angles, one in each quadrant of the circle, as shown in the remarks on Fig. 58; while the table gives but one angle (that in the first quadrant, or between 0° and 90°), for each sine, etc. The four angles thus corresponding to any one sine, etc., are necessarily supplements of each other. The circumstances of the case must determine which of the four is the required angle. Thus, in Fig. 46, x is evidently between 0° and 90°; while in Fig. 47 it is between 90° and 180°.

Remarks on the following Table of Sines, Etc.

The following table does not contain secants or cosecants, but these may be found thus: for any angle not exceeding 90°:

Secant.—Divide 1 by the cosine. Cosecant.—Divide 1 by the sine.

For versed sines, see Table, p. 170.

For angles exceeding 90°, and less than 180°, take the angle from 180°; if between 180° and 270°, take 180° from the angle; if between 270° and 360°, take the angle from 360°; then, in each case, the sine, cosine, tangent, or cotangent of the remainder, as given by the table, is the sine, cosine, tangent, or cotangent of the angle itself; and the secant or cosecant of the remainder, found as first directed above, is the secant or cosecant of the angle.

For Versed Sines, p. 122, see Table, pages 170 to 192.

Deg. 89

| 5 | 1 | 6 | 18 | 7 | 16 | 19 | 4 | 85 | 65 | = | 0 | 6 | 00 | ~ | 9 | 10 | 4 | 00 | 90 | - | 0 | | 1 |
|---------|---|--------------------------|---|--|--|--|--|---|--|--|--|--|---|--|--|--|--|--|--|--|--|--|----------------|
| Cosine. | 1 | | 5922 0063995 006399 156-2590 9999795 3842 0122170 012217 81-84704 9999254 | -0005818 000582 1718 - 873 -9999998 58 23 -0066904 -006690 149 - 4650 -9999776 37 43 -0125079 -012508 79 - 94343 -9993218 17 -006681 -0066 | 18166666 | -0011636 - 001163 859 + 4363 - 99999993 - 56 26 -0072721 -007272 137 - 5075 -9999736 35 45 -0130896 -013090 76 - 39000 -9999143 15 -0130896 -013090 -013 | $-0014544 + 001454 + 687 \cdot 5488 + 9999989 + 56 \cdot 26 \cdot 007563 + 00$ | -0017453 - 001745 - 572 - 9572 - 9999985 - 5427 - 0078539 - 007854 - 127 - 3213 - 9999692 - 3347 - 0136713 - 013672 - 73 - 13899 - 9999065 - 13877 - 1287 | $-0020362 - 002036 \pm 91 - 1060 - 99999979 + 5328 - 0081448 - 0081445 + 122 - 7739 - 9999668 + 3248 - 0139622 - 013962 + 1761507 - 9999025 + 122 - 122$ | 9998984 | 9998942 | 0068666 | 9988866 | 9998812 | 9928666- | 9998720 | -9998673 | .9998625 | -9998577 | -9998527 | 9998477 | | Sine. |
| Cotang. | - | 83.84350 | 81.84704 | 79-94343 | $-0008727 -000872 -1145 \cdot 915 -9999996 -1724 \cdot 0069813 -006981 -143 \cdot 2371 -9999756 -3644 \cdot 0127987 \cdot 012799 -78 \cdot 12634 -9999181 -12634 -12644 -12644 -12644 -12644 -12644 -12644 -12644 -12644 -12644 -126$ | 76-39000 | 74.72916 | 73-13899 | 71-61507 | $-0023271 - 0023271 + 29 \cdot 7175 - 9999973 - 52 \cdot 29 - 0084357 - 008436 - 118 \cdot 5401 - 9999644 - 3149 \cdot 0142530 - 014254 - 70 \cdot 15334 - 999898 - 999898 - 99989 - 99989 - 999898 - 999898 - 999898 - 99989 - 99$ | -0026180 - 002618 - 381 - 9709 - 9999966 - 651 - 30 - 0087265 - 008726 - 114 - 5886 - 9999619 - 30 - 50145439 - 014545 - 6875008 - 9998942 - 9998944 - 9998942 - 9998942 - 9998942 - 9998942 - 9998942 - 9998940 - 9998940 - 9998940 - 9998940 - 9998940 - 9998940 - 9998940 - 999 | $-0029089 -002908 - 343 \cdot 7737 - 9999958 - 50 = 31 \cdot 0090174 + 009017 + 110 \cdot 8920 - 9999593 - 2951 - 014834 - 014836 - 67 \cdot 40185 - 9998900 - 999958 - 9998900 - 999958 - 9999900 - 999900 - 99$ | +0.031998 + 0.031999 + 312 + 5213 + 9999949 + 9499949 + 9999967 + 2862 + 9999967 + 2862 + 9151256 + 915127 + 6010647 + 9998856 + 9999867 + 986267 + 9862856 + 986286 | 2.0034907.003490 $286.4777.9999939$ $48.33.0095992.009599$ $104.1709.9999539$ $2753.0154165.015418$ $64.85800.9998812$ | $-0037815 \cdot 003781 \cdot 264 \cdot 4408 \cdot 9999928 \cdot 47 \cdot 34 \cdot 0098900 \cdot 009890 \cdot 101 \cdot 1069 \cdot 99999511 \cdot 2654 \cdot 0157073 \cdot 015709 \cdot 63 \cdot 65674 \cdot 9998766 \cdot 1017078 \cdot 1017078 \cdot 101709 $ | $-0040724 + 004072 \\ 245.5519 \\ -9999917 \\ 146 \\ 35 \\ -0101809 \\ -010181 \\ $ | 61-38290 -9998673 | 57 0165799 016582 60 30582 9998625 | $770049451 \cdot 0049451 \cdot 202 \cdot 2187 \cdot 9999878 \cdot 43 \cdot 38 \cdot 0110535 \cdot 011054 \cdot 90 \cdot 46333 \cdot 9999389 \cdot 2258 \cdot 0168707 \cdot 016873 \cdot 59 \cdot 26587 \cdot 9998577 \cdot 0168707 \cdot 016878 \cdot 0168707 \cdot 016878 \cdot 016877 \cdot 016878 \cdot 016878 \cdot 016877 \cdot 016878 \cdot 016877 \cdot 016878 \cdot 016878 \cdot 016877 \cdot 016877$ | $8\cdot 0052360\cdot 005236 \cdot 190\cdot 9841\cdot 9999863 \cdot 4239\cdot 0113444\cdot 011345 \cdot 88\cdot 14357\cdot 9999357\cdot 2159\cdot 0171616\cdot 017164 \cdot 58\cdot 26117\cdot 9998527 \cdot 9999357\cdot 2159\cdot 0171616\cdot 017164 \cdot 58\cdot 26117\cdot 9998527 \cdot 9998527 \cdot 9999367 \cdot 99998677 \cdot 99998677 \cdot 9999877 \cdot 999977 \cdot 99977 \cdot $ | $9.0055268 \cdot 005526 \cdot 180.9322 \cdot 9999847 \cdot 4140 \cdot 0116353 \cdot 011636 \cdot 85.93979 \cdot 9999323 \cdot 20 \cdot 60 \cdot 0174524 \cdot 017455 \cdot 57.28996 \cdot 9998477 \cdot 017455 \cdot 017455 \cdot 017457 \cdot 01747 \cdot 017457 $ | | Tang. |
| Tang. | 1 | -011927 | -012217 | -012508 | 012799 | -013090 | -013381 | 013672 | -013963 | -014254 | -014545 | -014836 | -015127 | 015418 | -015709 | -016000 | -016291 | 016582 | -016873 | -017164 | -017455 | | Cotan. |
| Sine. | 1 | 0119261 | 0122170 | 0125079 | 0127987 | 0130896 | 0133805 | 0136713 | 0139622 | 0142530 | 0145439 | 0148348 | 0151256 | 0154165 | 0157073 | 0159982 | 0162890 | 0165799 | 0168707 | 0171616 | 0174524 | | Cosine. Cotan. |
| - | Ì | 941 | 842 | 743 | 644 | 545 | 446 | 347 | 248 | 149 | 0 20 | 951 | 8.52 | 7.53 | 654 | 555 | 4 56 | 357 | 258 | 1 59 | . 090 | | 11 |
| - | 1 | 33 | 5 3 | 6 3 | 63 | 6 3 | 43 | 3 | 80 | 43 | 9 3 | 8 | 7 20 | 62 | 12 | 65 | 2 | 1 | 9 2 | 7 20 | 3 2 | | - |
| Cosine. | | 1866666 | 626666- | -999977 | -999975 | -999973 | -999971 | 6966666 | 996666- | -999964 | 1966666 | -999959 | -936666 | -999953 | 1966666 | 8166666 | -999945 | -999942 | 8866666 | -999935 | -999932 | | Sine. |
| Cotang. | 1 | 163-7001 | 156-2590 | 149-4650 | 143-2371 | 137-5075 | 132-2185 | 127-3213 | 122-7739 | 118-5401 | 114-5886 | 110-8920 | 107-4264 | 104-1709 | 101-1069 | 98-21794 | 95-48947 | 92-90848 | 90-46333 | 88-14357 | 85-93979 | | Tang. |
| Tang. | 1 | 801900 | 006399 | 069900 | 006981 | 007272 | 007563 | 007854 | 008145 | 008436 | 921800 | 100000 | 808600 | 0009599 | 068600 | 010181 | 010472 | 010763 | 011054 | 011345 | 011636 | | Cotan. |
| Sine. | 1 | 9801900 | 0063995 | 0066904 | 0069813 | 0072721 | 0075630 | 0078539 | 0081448 | 0084357 | 0087265 | 90000174 | 8808600 | 0095992 | 0068600 | 0101809 | 0104718 | 0107627 | 0110535 | 0113444 | 0116353 | | Cosine. Cotan. |
| - | + | 17 | 55 | 33 | 24 | - 92 | 92 | 27 | 88 | 62 | 30 | 31 | 35 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 01 | | |
| - | 1 | 800 | 969 | 58 | 57 | 565 | 55 | 54 | 53 | 52 | 51 | 50 | 49 | 48 | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 40 | 1 1 |
| Cosine. | 1 | 1.0000001 | 1-000000-1 | 8666666 | 96666666 | -9999993 | 6866666 | -9999985 | 6266666 | 9999973 | 99666666 | 89666666 | -9999949 | 68666666 | 82666666 | 9999917 | -9999905 | -9999892 | 8786666 | -986666 | 9999847 | 9999831 | Sine. |
| Cotang. | | 0000000 000000 Infinite. | 0002909 000291 3437-746 1-000000 | 1718-873 | 1145-915 | 859-4363 | 687-5488 | 572-9572 | 491-1060 | 429-7175 | 381-9709 | 343-7737 | 312-5213 | 286.4777 | 264-4408 | 245.5519 | $5_{1} \cdot 0043633 \cdot 0043633 \cdot 229 \cdot 1816 \cdot 9999905 \cdot 45 \cdot 36 \cdot 0104718 \cdot 0104712 \cdot 95 \cdot 48947 \cdot 9999452 \cdot 2456 \cdot 0162890 \cdot 016291 \cdot 016291$ | $6 \cdot 0046542 \cdot 004654214 \cdot 8576 \cdot 99998924437 \cdot 0107627 \cdot 010763 \cdot 92 \cdot 90848 \cdot 999942123$ | 202-2187 | 190-9841 | 180-9322 | 20 -0058177 -005817 171-8854 -9999831 40 | Tang. |
| Tang. | | 000000- | .000291 | -000582 | -000872 | .001163 | 001454 | -001745 | .002036 | -002327 | .002618 | 806500 | -003199 | -003490 | .003781 | -004072 | -004363 | -004654 | -004945 | -005236 | -005526 | -005817 | Cot n. |
| Sine. | | 0000000 | -0002909 | 0005818 | -0008727 | -0011636 | -0014544 | -0017453 | -0020362 | -0023271 | 0026180 | -0029089 | -0031998 | -0034907 | -0037815 | -0040724 | -0043633 | -0046542 | -0049451 | -0052360 | -0055268 | -0058177 | Cosine. |
| | 1 | 0 | 1 | 63 | | | | 9 | | | 6 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 1 |

| | | 121 | DIM | . 0. | | 117 | 100, | - | - | | 44.0 | -, | - | | | | |
|--------|---------|---|---|--|--|--|--|--|---|--|--|--|---|--|--|----------------|----------|
| f | | 19 | 17 | 15 | 13 | 12 | 11 | 6 | 00 | 200 | 0 0 | 4 | 00 0 | i | 0 | 1- | 88 |
| | Cosine. | 0174524 017455 57-28996 9998477 6021 0235598 023566 42-43346 9997224 3941 0293755 029388 34-02730 9995684 | -0180341 018037 55-44151 9998374 5823 0241414 024148 41-41058 9997086 3743 0299570 33 36619 9995512 | $-0183249 \cdot 018328 \cdot 34 \cdot 56130 \cdot 9998321 \cdot 5724 \cdot 0244321 \cdot 024439 \cdot 40 \cdot 91741 \cdot 9997015 \cdot 5644 \cdot 03024 \cdot 18 \cdot 030261 \cdot 53 \cdot 04517 \cdot 999534 \cdot 09186158 \cdot 018619 \cdot 53 \cdot 70858 \cdot 09998267 \cdot 5625 \cdot 0247230 \cdot 024730 \cdot 40 \cdot 42583 \cdot 9996943 \cdot 3545 \cdot 0305385 \cdot 030552 \cdot 32 \cdot 73026 \cdot 9995336 \cdot 09186158 \cdot 018619 \cdot 01$ | $-0.189066 \cdot 0.18910 \cdot 32.88211 \cdot 9998213 \cdot 55 \cdot 26 \cdot 0.250138 \cdot 0.25021 \cdot 39.96546 \cdot 9996871 \cdot 34 \cdot 146 \cdot 0.308293 \cdot 0.30843 \cdot 32.42129 \cdot 9995247 \cdot 0.000167 \cdot 0.00$ | $\frac{194883}{994883} \cdot \frac{19492}{919492} \cdot \frac{1}{5} \cdot \frac{1081}{998} \cdot \frac{10}{998} \cdot 10$ | -0197791 -019783 50-54850 -9998044 52 29 -0258862 -025894 38-61773 -9998649 31 49 -0317015 -031717 31 52839 -9994974 | -0200099 020074 48751072 9887800 5150 020109 020159 55 1964 5850 5150 01952 020001 051952 020001 55 1961 052000 050001 0500001 050001 050001 050001 050001 0500001 050001 0500001 050001 | $11.0206516.020656\ 48.41208.9997867\ 49\ 32.0267585\ 026768\ 37.35789\ 9996419\ 28\ 52.0325737\ 032591\ 30.68330\ 9994693$ | -0209424 - 020947 + 47.73950 - 9997807 + 4833 - 027049 - 027049 - 027049 - 0270490 - 0270490 - 0270490 - 0270490 - | (3.0212332.021238 47.08534 9997634 9497745 977340 927340 927520 36.55255 9996182 2552 9334459 933464 29.88229 9994405 9334459 933464 29.88229 9994405 933464 9334 | $5.0218149 - 021820 \\ 45.82935 \cdot 9997620 \\ 45.82935 \cdot 9997620 \\ 45.86.0279216 \\ -0279321 \\ 35.80055 \cdot 9996101 \\ 24.56 \cdot 9996101 \\ 24.56 \cdot 9337366 \\ -033736 \\ -03376$ | $6.0221057\cdot022111 45\cdot22614 \cdot 9997556 \cdot 44\cdot37 \cdot 0282124 \cdot 028223 \cdot 35\cdot43128 \cdot 996020 \cdot 23\cdot57 \cdot 034027 \cdot 9997509 \cdot$ | 7-0223965-02240244-63859-99974924358-0285032-023514-35-06354-9995354-034508-0345181-034358-23-12200-3994110 8-055873-059593-44-65859-02466-289-0287940-028805-34-71511-9995854-2159-0346088-034629-29-29-994009 | 40 -0290847 -029097 34-36777 -9995770 20 60 -0348995 -034920 28-63625 -9993908 | Sine. | Deg. 88. |
| | Cotang. | 34-02730 | 33-36619 | 32-73026 | 32-42129 | 31-82051 | 31.52839 | 30-95992 | 30.68330 | 30-41158 | 29.88229 | 29.62449 | 29-37110 | 28.87708 | 28.63625 | Tang. | |
| | Tang. | -029388 | -029970 | 030222 | 030843 | -031426 | -031717 | -032299 | -032591 | 032882 | 033464 | -033755 | -034047 | 034629 | -034920 | Cotan. | |
| 1 Deg. | Sine. | 0293755 | 0299570 | 0305385 | 0308293 | 0314108 | 0317015 | 0322830 | 0325737 | 0328644 | 0334459 | 0337366 | 0340274 | 0346088 | 0348995 | Cosine. Cotan. | |
| | - | 41. | 43 | 45 | 46. | 18 | 49 | 51 | 55 | 53 | 55 | 99 | 57 | 59 | 09 | 11 | L |
| | | 38 | 37 | 35 | 33 | 32 | 31 | 29 | 28 | 27 | 25 | 24 | 23 | 2 2 2 | 20 | - | 88 |
| | Cosine. | 9997156 | 9807086 | 9996943 | 17899999 | 9996724 | 9996649 | 9996497 | -9996419 | 9996311 | 9996262 | 1019666 | 9996020 | 9995854 | 9995770 | Sine. | Deg. 88. |
| | Cotang. | 42-43346 | 41-41058 | 40-91741 | 39-96546 | 39-05677 | 38-61773 | 37.76861 | 37-35789 | 36-95600 | 36-56265 | 35-80055 | 35-43128 | 35-06954 | 34-36777 | Tang. | |
| 100 | Tang. | -023566 | 024148 | 024439 | 025021 | -025603 | 025894 | 026477 | 891920- | 027059 | 027350 | -027932 | 028223 | 028514 | -029097 | Cotan. | |
| Deg. | Sine. | 0235598 | 0241414 | 0244322 | 0250138 | 0255954 | 0258862 | 0264677 | 0267585 | 0270493 | 0273401 | 0279216 | 0282124 | 0285032 | 0290847 | Cosine. Cotan. | |
| - | | 526 | 183 | 25 | 26 | 28 | 68 | 31 | 35 | 33 | 35 | 36 | 37 | 30 00 | 40 | 1 | |
| 7 | - | 60 | 58 | 56 | 55 54 | 53 | 1 52 | 7 50 | 7 49 | 48 | 446 | 45 | 3 44 | 43 | 41 | - | 0 |
| - | Cosine. | 9998477 | 9998374 | 999832 | 9998212 | 1018666 | -9998044 | 262666- | -9997867 | -9997807 | 999774 | 9997626 | 9997556 | 9997498 | 999736 | Sine. | Dog 88. |
| | Cotang. | 57-28996 | 55-44151 | 54-56130 | 52-88211 | 51-30315 | 50-54850 | 49.10388 | 48-41208 | 47-73950 | 47-08534 | 45-82935 | 45-22614 | 44.63859 | 43-50812 | Tang. | |
| | Tang. | -017455 | 018037 | 018328 | 018810- | -019492 | -019783 | -020074 | -020656 | -020947 | 021238 | 021820 | 1111220 | 022402 | -0222984 | Cotan. | |
| L Deg. | Sine. | 0174524 | 0180341 | 0183249 | 9906810- | 0194883 | 10197791 | 0203608 | -0206516 | -0209424 | 0212332 | 0218149 | -0221057 | 0223965 | 19 ·0229781 ·022984 43·50812 ·9997360 4 | Cosine. | |
| 11 | - | 10- | | 30 d | 20 4 | 2 1- | | 10 | 11 | 12 | 5 4 | 15 | 91 | 2 2 | 110 | 1. | |
| | 1 | 1 * | | | | | | | - | | | | | | | | |

| 1 | | 19 | 18 | 17 | 91 | 15 | 14 | 13 | 12 | 11 | 0: | 6 | 00 | 7 | 9 | 9 | 4 | 33 | G.S. | 1 | 0 | | - |
|--------|-------------------|--|---|--|--|---|--|--|--|--|--|--|---|--|--|---|--|--|--|---|--|--|---------|
| | Cosine. | 0.0348995 -034920 28-63625 -9993908 6021 -0410037 -041038 24-36750 -9991590 3941 -0468159 -046867 21.33685 -9989035 19 | $0.351902 \cdot 0.35212 \cdot 28.39939 \cdot 9993806 \cdot 5922 \cdot 0.412944 \cdot 0.41329 \cdot 24.19571 \cdot 9991470 \cdot 0.842 \cdot 0.471065 \cdot 0.471065 \cdot 0.47158 \cdot 21.20494 \cdot 9988899 \cdot 0.000000000000000000000000000000000$ | $0.355899 \cdot 0.355632 \cdot 22 \cdot 16642 \cdot 9993704 \cdot 15820 \cdot 0415850 \cdot 041621 \cdot 24 \cdot 02632 \cdot 9991350 \cdot 3743 \cdot 0473970 \cdot 047450 \cdot 21 \cdot 07466 \cdot 9988761 \cdot 0355899 \cdot 035599 \cdot 035599 \cdot 035599 \cdot 0355999 \cdot 035599 \cdot 0355999 \cdot 035599 $ | $-0.357716 \\ -0.357716 \\ -0.35721 \\ -0.476876 \\ -0.476876 \\ -0.4761741 \\ -0.49596 \\ -9.988623 \\ -0.476876 \\ -0.47741 \\ -0.94596 \\ -9.988623 \\ -0.9882$ | $-0.360623 -0.036085 \times 27.71174 \\ -9993495 \times 15625 \\ -0.421663 -0.42203 \times 23.69453 \\ -9988484 \\ -9988484 \\ -9988484 \\ -9988484 \\ -9988484 \\ -9988484 \\ -9988484 \\ -9988484 \\ -9988484 \\ -99888484 \\ -9988884 \\ -9988884 \\ -9988884 \\ -9988884 \\ -9988884 \\ -9988884 \\ -998888 \\ -99888 \\ -99888 \\ -998888 \\ -998888 \\ -998888 \\ -998888 \\ -998888 \\ -998888 \\ -$ | $0.363530 \cdot 0.363771 \cdot 27 \cdot 48985 \cdot 99933390 \cdot 55 \cdot 26 \cdot 0.424569 \cdot 0.42456 \cdot 9.3205 \cdot 9990983 \cdot 34 \cdot 46 \cdot 0.482687 \cdot 0.48325 \cdot 20 \cdot 69322 \cdot 9988344 \cdot 11 \cdot$ | $+0.36668 27\cdot27148 9993284 54 27 -0427475 042786 23\cdot37177 9990859 33 47 -0485592 -048616 20\cdot56911 -9988203 13 -048568 27 -048616 20\cdot56911 -9988203 13 -048618 20\cdot56911 -9988203 13 -9988203 19 -9988203 19 -9988203 19 -9988203 19 -9988203 19 -9988203 19 -9988203 19 -9988203 19 -998820 19 -998820 19 -998820 19 -998820 19 -998820 19 -998820 19 -998820 19 -998820 19 -998820 19 -99888 19 -99888 19 -99888 19 -99888 19 -99888 19 -99888 19 -99888 19 -99888 19 -99888 19 -99888 19 -99888 19 -9988 19 -99888 19 -99888 19 -9988 19 -99888 19 -99888 19 -9988 19 -99888 19 -99888 19 -$ | -0.369344 + 0.36959 + 27 + 0.5655 + 9993177 + 15328 + 0.430382 + 0.43078 + 23 + 21366 + 9990734 + 3248 + 0.488498 + 0.48908 + 0.48648 + 9988061 + 9988061 + 1000000000000000000000000000000000 | -0372251 -0372261 + 0694498 -0993069 + 069328 -043369 + 0693288 -043369 + 0690669 + 0690669 + 069060 | $-0375158 \\ -037542 \\ 26 \\ -63669 \\ -99296 \\ -9990482 $ | -9987631 | $1.0380971 \cdot 038124 \cdot 26 \cdot 22963 \cdot 9992740 \cdot 4932 \cdot 0442006 \cdot 044243 \cdot 22 \cdot 60201 \cdot 9990227 \cdot 2852 \cdot 0500119 \cdot 050074 \cdot 19 \cdot 97021 \cdot 9987486$ | $ 2.0383878 \cdot 038416 \cdot 26 \cdot 03073 \cdot 9992629 + 833 \cdot 0444912 \cdot 044535 \cdot 22 \cdot 45409 \cdot 9990098 \cdot 27 \cdot 53 \cdot 0503024 \cdot 050366 \cdot 19 \cdot 85459 \cdot 9987340 \cdot 10 \cdot $ | -9987194 | $4.0389692.038998 \\ 25.64183 \\ -9992404 \\ 4635.0450724 \\ -045118 \\ 22.16398 \\ -9989837 \\ 25[55] \\ -0508835 \\ -050949 \\ 19.62729 \\ \\ -9987046 \\ -045118 \\ 22.16398 \\ -045118 \\ 22.16398 \\ -045118 \\ $ | $\begin{array}{cccccccccccccccccccccccccccccccccccc$ | $16 \cdot 0395505 \cdot 039581 \ 25 \cdot 26436 \cdot 9992176 \ 44 37 \cdot 0456536 \cdot 045701 \ 21 \cdot 88125 \cdot 9989573 \ 23 57 \cdot 0514645 \cdot 051532 \ 19 \cdot 40513 \ \cdot 9986748 \ 3 \cdot 10514645 \ \cdot 3986748 \ \cdot 39$ | 17.0398411.039872.25-07975.9992060.4338.0459442.045992.21.74256.9989440.2258.0517550.051824.19.29592.9986598 | $18.0401318.040164124.89782:9991944142399.0462347.04628421-60563-998930612169.0520455\cdot052116119\cdot18793\cdot99864477818181818181818181818181818181818181$ | $19 \cdot 0404224 \cdot 040455 \cdot 24 \cdot 71851 \cdot 9991827 \cdot 41 \cdot 40 \cdot 0465253 \cdot 046575 \cdot 21 \cdot 47040 \cdot 9989171 \cdot 20 \cdot 60 \cdot 0523360 \cdot 052407 \cdot 19 \cdot 08113 \cdot 9986295 \cdot 21 \cdot 47040 \cdot 9989181 \cdot 20 \cdot 21 \cdot 21 \cdot 21 \cdot 21 \cdot 21 \cdot 21 \cdot 2$ | | Sine. |
| | Cotang. | 21.33685 | 21-20494 | 21-07466 | 20-94596 | 20-81882 | 20.69322 | 20-56911 | 20-44648 | 20.32530 | 20-20555 | $0.0378065 \cdot 037833 \cdot 26.43160 \cdot 9992851 \cdot 50 \cdot 31 \cdot 0439100 \cdot 043952 \cdot 22.75189 \cdot 9990355 \cdot 2951 \cdot 0497214 \cdot 049782 \cdot 20.08719 \cdot 9987631 \cdot 20.08719 \cdot 20$ | 19-97021 | 19.85459 | $3 \cdot 0386785 \cdot 0386785 \cdot 038707/25 \cdot 83482 \cdot 9992517 \cdot 4734 \cdot 0447818 \cdot 0447818 \cdot 044826 \cdot 22 \cdot 30809 \cdot 9989968 \cdot 2654 \cdot 0505929 \cdot 050657 \cdot 19 \cdot 74029 \cdot 9987194 \cdot 0447819 \cdot 0447819 \cdot 0447818 \cdot 0447819 \cdot 04$ | 19-62729 | 19-51558 | 19-40513 | 19-29592 | 19-18793 | 19-08113 | | Tang. |
| | Tang. | -046867 | -047158 | -047450 | -047741 | -048033 | -048325 | .048616 | -048908 | -049199 | -049491 | -049782 | -050074 | -050366 | -050657 | -050949 | .051241 | -051532 | 051824 | 052116 | .052407 | | Cotan. |
| 2 Deg. | Sint. | 0468159 | -0471065 | 0473970 | 0476876 | 0479781 | 0482687 | 0485592 | 0488498 | 0491403 | 0494308 | 0497214 | 0500119 | 0503024 | 0505929 | 0508835 | 0511740 | 0514645 | 0517550 | 0520455 | 0523360 | | Cosine. |
| 2 1 | _ | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 20 | 19 | 52 | 53 | 54 | 55 | 99 | 57 | 58 | 69 | 09 | | - |
| 1 | _ | 39 | 38 | 37 | 36 | 35 | 34 | 33 | 32 | 31 | 30 | 58 | 28 | 3 27 | 326 | 25 | 24 | 23 | 122 | 121 | 20 | | |
| | Cosine. | 9991590 | -9991470 | -9991350 | -9991228 | -9991106 | 8606666 | -9990858 | -9990734 | 3090666- | -9990482 | -999035 | -9990227 | 3600666- | 3966866 | -9989837 | 9989706 | 9989573 | -998944(| 9989306 | 1216866- | | Sine. |
| 4 | Cotang. Cosine. | 24-36750 | 24-19571 | 24-02632 | 23-85927 | 23-69453 | 23-53205 | 23-37177 | 23-21366 | 23-05767 | 22-90376 | 22-75189 | 22-60201 | 22-45409 | 52-30809 | 22-16398 | 22-02171 | 21.88125 | 21-74256 | 21-60563 | 21.47040 | | Tang. |
| | Tang. | 041038 | 041329 | 041621 | 041912 | 042203 | 042495 | 042786 | 043078 | 043369 | 043660 | 043952 | 044243 | 044535 | 044826 | 045118 | 045409 | 045701 | 045992 | 046284 | 046575 | | Cotan. |
| eg. | Sine. | 0410037 | 0412944 | 0415850 | 0418757 | 0421663 | 0424569 | 0427475 | 0430382 | 0433288 | 0436194 | 0439100 | 0442006 | 0444912 | 0447818 | 0450724 | 0453630 | 0456536 | 0459442 | 0462347 | 0465253 | | Cosine. |
| 2 Deg. | , | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | | - |
| | , | 9 | 59 | 58 | 57 | 56 | 55 | 54 | 53 | 52 | 51 | 50 | 49 | 48 | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 40 | 1 |
| | Cosine. | 9993908 | 9993806 | -9993704 | -9993600 | 9993495 | -9993390 | -9993284 | -9993177 | -9993069 | 9992960 | -9992851 | 9992740 | 9992629 | -9992517 | -9992404 | -9992290 | -9992176 | 9992060 | -9991944 | -9991827 | -9991709 | Sine. |
| | Cotang. | 28-63625 | 28-39939 | 28-16642 | 27-93723 | 27-71174 | 27-48985 | 27-27148 | 27-05655 | 26.84498 | 26-63669 | 26-43160 | 26-22963 | 26-03073 | 25.83482 | 25-64183 | 25-45170 | 25-26436 | 25-07975 | 24.89782 | 24-71851 | 24.54175 | Tang. |
| 1 | Tang. | 034920 | -035212 | -035503 | -035794 | -036085 | -036377 | -036668 | -036959 | -037250 | -037542 | -037833 | -038124 | -038416 | -038707 | -038998 | -039290 | -039581 | 039872 | -040164 | -040455 | -040746 | Cotan. |
| 2 Deg. | Sine. | 0348995 | 0351902 | 0354809 | 0357716 | 0360623 | 0363530 | -0366437 | 0369344 | -0372251 | -0375158 | -0378065 | 0380971 | -0383878 | -0386785 | -0389692 | -0392598 | -0395505 | 0398411 | 0401318 | -0404224 | 20 -0407131 -040746 24-54175 -9991709 40 | Cosine. |
| 2 | - | 10 | - | 63 | | | | 9 | 7 | | 6 | 10 | - | 2 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 1 |

NATURAL SINES AND TANGENTS TO A RADIUS I.

| | · 1 | 6 | 00 | 7 | 9 | 2 | 4 | 3 | 2 | - | 0 | 6 | 00 | 1 | 9 | 2 | 4 | 8 | 53 | - | 0 | ī | _ |
|--------|---------|---|---|--|--|---|---|---|--|--|---|--|--|--|--|--|---|--|--|--|---|---------------------------------------|------------------|
| 1 | | 052407 9-08113 9986295 6021 0584352 058535 17-08372 9982912 3941 0642420 064375 15-53398 9979343 19 | 15-46381 -9979156 18 | 8 | 16 | 9 1 | $0537883 \cdot 053866 \cdot 18 \cdot 56447 \cdot 9985524 \cdot 5526 \cdot 0598871 \cdot 059994 \cdot 16 \cdot 66811 \cdot 9982052 \cdot 3446 \cdot 0656934 \cdot 065835 \cdot 15 \cdot 18934 \cdot 9978399 \cdot 14 \cdot $ | 0.054158 + 0.054168 + 0.060187 + 0.0601775 + 0.060286 + 0.0540788 + 0.054078 | $\frac{1324393}{1654349} \cdot \frac{18.36553}{16985209} \cdot \frac{9985209}{169852} \cdot \frac{16960478}{1698578} \cdot \frac{16604678}{1698578} \cdot \frac{1660479}{1698578} \cdot \frac{166047}{1698578} \cdot \frac{166047}{1698578} \cdot \frac{166047}{1698578} \cdot \frac{166047}{1698578} \cdot$ | 11 | 7.1 | 60 | 7 | 0 | 3 | 2 | 5 | 2 | 2 | 3 | - | - ! | - |
| 1 | Cosine. | 134 | 115 | 0.529169.0529118.87106199859895895989589589589589589589699825703743.0648226106495915.3942719978968968968968968968968968968968968968968 | $0.533074 + 0.53282 \\ 18.76775 \\ \cdot 9985835 \\ 15.724 \\ \cdot 0593064 \\ \cdot 059410 \\ \cdot 16.83191 \\ \cdot 9982398 \\ \cdot 3644 \\ \cdot 0651129 \\ \cdot 065251 \\ \cdot 15.32535 \\ \cdot 9978779 \\ \cdot 053264 \\ \cdot 059410 \\ \cdot 059$ | 0.534979, 0.53574, 18.66556, 9985680, 5625, 0.595967, 0.69702, 16.74961, 99822225, 3545, 0.654031, 0.65543, 15.25705, 9978589 | 339 | 320 | 301 | $0.545597 \cdot 0.54741 \cdot 18 \cdot 26765 \cdot 9985050 \cdot 5229 \cdot 0607582 \cdot 060870 \cdot 16 \cdot 42827 \cdot 9981525 \cdot 3119 \cdot 0665641 \cdot 066712 \cdot 14 \cdot 98978 \cdot 9977821 \cdot 0646597 \cdot 064667 \cdot 06467 \cdot 064667 \cdot 064667 \cdot 064667 \cdot 064667 \cdot 064667 \cdot 064667 \cdot 06467 \cdot 064667 \cdot 06467 \cdot 06$ | $0.0549502 \cdot 0.056033 \mid 18.17080 \cdot 9984891 \mid 51 \mid 30 \cdot 0.010485 \cdot 0.01162 \mid 16.34985 \mid .9981348 \mid 30 \mid 50 \cdot 0.0688544 \cdot 0.067004 \mid 14.92441 \mid .9977627 \mid .007004 \mid .0$ | $-0552406 \cdot 055325 \cdot 18 \cdot 07497 \cdot 9984731 \cdot 56 \cdot 31 \cdot 0613389 \cdot 061454 \cdot 16 \cdot 27217 \cdot 9981170 \cdot 29 \cdot 51 \cdot 0671446 \cdot 067296 \cdot 14 \cdot 85961 \cdot 9977433 \cdot 12 \cdot $ | $0.0555311 \\ 1056616 \\ 17.98015 \\ 9984570 \\ 49132 \\ 90616292 \\ 9061746 \\ 16.19522 \\ 9977237 \\ 9977237 \\ 9977237 \\ 9977237 \\ 9987237 \\ 9$ | 2.0555215.05590817.88631.99844084833.0619196.06203816.118991.998081112757.06772511.067880114.73167.9977040 | $13.0561119.056200 \\ 17.79344 \\ \cdot 9984245 \\ \mid 4734 \\ \cdot 0622099 \\ \cdot 0622099 \\ \cdot 0622300 \\ \mid 16.04348 \\ \cdot 9980631 \\ \mid 2654 \\ \cdot 9980631 \\ \mid 2654 \\ \cdot 0680153 \\ \cdot 0680153 \\ \cdot 0680153 \\ \cdot 068173 \\ \mid 4.66885 \\ \mid 9976843 \\ \cdot 0680183 \\ \cdot 0680$ | (4.0564024.056492.17.70152.9984081.4635.0625002.062622.15.96866.9980450.2555.0683055.0683055.068465.14.60691.9976645.11.20164.11.2016.11.201 | $5.0566928.056784 \\ 17.61055 \\ \cdot 9983917 \\ \mid 45 \\ \mid 36.0627905 \\ \cdot 0627905 \\ \mid 062914 \\ \mid 15.89454 \\ \cdot 9980267 \\ \mid 24 \\ \mid 56.9957 \\ \cdot 0685957 \\ \cdot 068757 \\ \mid 14.54383 \\ \mid 9976445 \\ \mid 9976445 \\ \mid 9980267 \\ \mid 24 \\ \mid 56.9685957 \\ \cdot 068757 \\ \mid 14.54383 \\ \mid 9976445 \\ \mid 997645 \\ \mid 9976445 \\ \mid 997645 \\ \mid 9976445 \\ \mid 9976445$ | $6.0569832.057075 \\ 17.52051 \\ 1.9983751 \\ 14437 \\ 10630808 \\ 10630808 \\ 1063206 \\ 15.82110 \\ 10980084 \\ 22 \\ 57 \\ 1068859 \\ 1068859 \\ 1069049 \\ 114.48227 \\ 19976245 \\ 10688859 \\ 1068859 \\ 10688859$ | $770572736 \cdot 057367 \cdot 17 \cdot 43138 \cdot 9983585 \cdot 43138 \cdot 9983585 \cdot 43138 \cdot 998358 \cdot 15 \cdot 74833 \cdot 9979900 \cdot 22 \cdot 58 \cdot 0691761 \cdot 069342 \cdot 14 \cdot 42123 \cdot 9976045 \cdot 17 \cdot 1$ | $ \underbrace{8}_{0.0775640}, \underbrace{057659}_{17.34215}, \underbrace{05983418}_{9983418}, \underbrace{42}_{39}, \underbrace{0636614}_{0.636614}, \underbrace{063763}_{17.67663}, \underbrace{1567623}_{17.67663}, \underbrace{0694663}_{17.94663}, \underbrace{069634}_{17.34218}, \underbrace{14.36069}_{17.34218}, \underbrace{9975843}_{17.34218}, \underbrace{14.36069}_{17.34218}, 14.360$ | $90578544 + 057951 \\ 17.25580 + 9983250 \\ 9140 + 0639517 \\ 1064082 \\ 15.60478 + 9979530 \\ 20 \\ 37.60478 \\ 9979530 \\ 20 \\ 37.0697565 \\ 9979564 \\ 10.0697565 \\ 10.0697565 \\ 10.0697565 \\ 10.069756 \\ 10$ | | e. |
| 1 | so | 979 | 979 | 978 | 978 | 978 | 978 | 978 | 978 | 977 | 977 | 977 | 977 | 977 | 976 | 976 | 976 | 976 | 976 | 975 | 976 | | Sine. |
| - | 0 | 6. | 6. | 6. | .9 | 6. | 6. | 6. | 6. | 6. | 6. | 6. | 6. | 6. | 6. | 6. | 6. | 6 | 6. | 6 | 6. | | |
| | 80 l | 86 | 18 | 27 | 35 | 0.0 | 34 | 24 | 72 | 18 | 41 | 19 | 37 | 67 | 152 | 16 | 83 | 27 | 23 | 69 | 99 | 1 | |
| - | Cotang. | 33 | 63 | 194 | 325 | 557 | 89 | 22 | 155 | 88 | 24 | 828 | 95 | 31 | 89 | 105 | 43 | 85 | 21 | 091 | 00 | | Tang. |
| 1 | Cot | 5.5 | 5.4 | 5.3 | 5.3 | 5.5 | 5.1 | 5.1 | 5.0 | 4.9 | 4.9 | 4.8 | 4.7 | 4.7 | 4.6 | 4.6 | 4.5 | 4.4 | 4.4 | 4.3 | 4.3 | | E |
| | | 5 | 7 1 | 9 1 | = | 3 1 | 19 | 7 1 | 9 1 | 2 | 1 1 | 6 1 | 8 1 | 10 | 3 1 | 2 | 7 1 | 9 1 | 2 1 | 1 1 | 9 | - | _ |
| 1 | Ta g. | 37 | 99 | 95 | 25 | 54 | 83 | 12 | 41 | 71 | 00 | 53 | 58 | 88 | 17 | 46 | 75 | 040 | 34 | 63 | 92 | | Cosine. Cotan. |
| | Ed | 64 | 64 | 64 | 65 | 65 | 65 | 991 | 99 | 99 | 67 | 19 | 187 | 67 | 68 | 68 | 89 | 69 | 69 | 69 | 69 | | Jot |
| ľ | | 9 | 9 | 9 | 0.0 | 2 | 2 | 9 | 3 | 9 | 9 | 9 | ? | 2 | 9 | 9 | 9 | ? | ? | 9 | 9 | -! | 0 |
| 1 | . 1 | 120 | 325 | 226 | 129 | 03] | 934 | 336 | 735 | 341 | 544 | 146 | 348 | 251 | 153 | 355 | 357 | 359 | 191 | 965 | 999 | | 1e. |
| | Sine. | 42 | 45 | 48 | 51 | 54 | 56 | 598 | 62 | 656 | 683 | 714 | 74: | 77 | 80 | 83 | 85 | 888 | 91 | 94 | 97 | | Sir |
| | 02 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 99 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | | Ö |
| - War | | = | 65 | 3 | 4 | 2 | 9 | - | 00 | 6 | 0 | = | 3 | 50 | 7 | 2 | 9 | - | 8 | 6 | ċ | | - |
| 1 | | 6 | 8 | 74 | 9 | 5 | 4 | 33 | 65 | - | 00 | 6 | 00 | 7 | 9 | 5 | 7 | D. | 54 | 13 | 0 | | |
| 1 | | . es | 53 | 0 3 | 8 | 5 3 | 200 | 73 | 13 | 53 | 8 | 0 30 | 1 2 | 1 2 | 25 | 0 2 | 72 | 4 | 0 2 | 6 2 | 0 | - | - |
| 1 | Cosme. | 91 | 74 | 57 | 39 | 22 | 05 | 87 | 70 | 52 | 34 | 17 | 66 | 81 | 63 | 45 | 56 | 08 | 06 | 7.1 | 53 | | e. |
| | 081 | 82 | 82 | 82 | 82 | 82 | 82 | 81 | 81 | 81 | 81 | 81 | 80 | 80 | 80 | 80 | 80 | 80 | 79 | 7.9 | 7.9 | | Sine. |
| 1 | 0 | .99 | -99 | 66. | .99 | -99 | -99 | 66. | 66. | 66. | -99 | -99 | -99 | -99 | -99 | -99 | 66. | 66. | 66. | .99 | -99 | | 02 |
| | 100 | 72 | 95 | 05 | 91 | 61 | 11 | 39 | 15 | 27 | 35 | 17 | 22 | 166 | 18 | 99 | 54 | 01 | 333 | 23 | 18 | | |
| | ang | 83 | 86 | 15 | 31 | 49 | 89 | 87 | 07 | 28 | 49 | 72 | 95 | 18 | 43 | 68 | 94 | 21 | 48 | 169 | 04 | | ngn |
| | Cotang. | 0.7 | 8.9 | 6.9 | 8.8 | 8.7 | 9.6 | 3.5 | 3.5 | 3.4 | 3.3 | 3.5 | 3.1 | 3.1 | 3.0 | 5.9 | 3.8 | 8.0 | 2.4 | 9.9 | 9.0 | | Tang. |
| | | | H | H | = | = | 1 | = | 16 | = | = | = | 1 | 1 | = | 7 | 7 | = | = | = | = | | |
| | Tang. | 355 | 327 | 119 | 110 | 702 | 994 | 988 | 578 | 370 | 162 | 154 | 746 | 38 | 330 | 322 | 114 | 903 | 861 | 190 | 85 | | Cotan. |
| | an | 585 | 588 | 591 | 594 | 597 | 598 | 805 | 60 | 808 | 611 | 614 | 617 | 520 | 325 | 326 | 356 | 335 | 534 | 837 | 64(| = | ots |
| | | 9 | 0 | 0 | 0 | 0 | 0 | o | ō | o | o | o | o | Ö | o | o | o | ē | ō | 9 | Ó | | 0 |
| | | 52 | 99 | 60 | 64 | 67 | 171 | 7.5 | 78 | 82 | 85 | 88 | 92 | 96 | 66 | 02 | 05 | 80 | 11 | 114 | 11 | = | ie. |
| | Sine. | 343 | 372 | 100 | 930 | 959 | 886 | 117 | 146 | 375 | 104 | 133 | 162 | 16 | 220 | 550 | 279 | 308 | 337 | 366 | 395 | | Sir |
| 9 | 00 | 058 | 058 | 990 | 059 | 950 | 990 | 960 | 90 | 90 | 90 | 190 | 190 | 190 | 390 | 90 | 390 | 90 | 90 | 90 | 90 | | Co |
| Sarr o | _ | - | 67 | 3 | 4 | 5 | 9 | - | 8 | 6 | 0 | - | ₹ 62 | 3 | 4 | 5 | 6 | 7 | 00 | 6 | 0 | | Cosine. |
| 1 | | 2 | 92 | 80 | 7 2 | 6.2 | 55 | 4 | 33 | 20 | 13 | 63 | 93 | 8 | 73 | 63 | 53 | 43 | 333 | 200 | 14 | 0 | |
| | | 9 | 3 5 | 3 | 5 | 5 | 5 | 7 | 315 | 0 | 5 | 5 | 0 | * | 54 | 4 | 74 | 4 | 5 4 | 84 | 04 | 4 | - |
| | ne. | 29 | 14 | 86 | 83 | 68 | 52 | 36 | 209 | 050 | 89 | 73 | 57 | 40 | 24 | 80 | 91 | 75 | 58 | 413 | 25 | 08 | e. |
| | Cosine. | 88 | 86 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 84 | 84 | 84 | 84 | 84 | 84 | 83 | 83 | 83 | 83 | 83 | 83 | Sine. |
| | 0 | -99 | 05269918-97552 .9986143 5922 .0587256 .058827 16.99895 .9982742 3842 .0645323 .064667 1 | 66. | .99 | 66. | .99 | 66- | .99 | 96. | 66. | .99 | 66. | .99 | 66. | .99 | .99 | 66. | .99 | .99 | .99 | 20 0581448 058243 17.16933 9983082 40 | 44 |
| 3 | | 0 | 25 | 96 | 75 | 96 | 17 | 17 | 53 | 65 | 98 | 16 | 15 | 31 | 14 | 25 | 25 | 51 | 38 | 15 | 80 | 33 | |
| | rng | 2 | 75 | 71 | 67 | 65 | 64 | 64 | 65 | 67 | 70 | 74 | 80 | 86 | 93 | 011 | 10 | 20 | 31 | 43 | 55 | 69 | Tang. |
| | Cotang. | 0.6 | 8.9 | 8 | 8.7 | 9.8 | 8:5 | 8.4 | 8.3 | 8.5 | 8 | 8.0 | 7.9 | 7.8 | 7.7 | 7.7 | 9.1 | 7.5 | 7.4 | 7.3 | 7.2 | 7.1 | F |
| | 0 | = | - | | - | - | - | 3 | 1 | - | 3 | 10 | 1 | ~ | 1 | 1 | 1 | 1 5 | 1 / | 116 | | 2 | |
| | Tang. | 107 | 365 | 166 | 88 | 574 | 366 | 158 | 148 | 741 | 935 | 32 | 516 | 906 | 200 | 195 | 784 | 078 | 367 | 399 | 951 | 24 | an. |
| | an | 59 | 52 | 52 | 53 | 53 | 538 | 54 | 54 | 54 | 55 | 55 | 55 | 55 | 56 | 56 | 99 | 57 | 57 | 57 | 57 | 28 | tot |
| | - | 9 | ċ | O | O | 0 | 0 | o | 0 | 0 | 0 | 9 | 0 | 0 | 9 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1 | RA | 64 | 69 | 74 | 79 | 83 | 000 | 93 | 16 | 02 | 90 | 111 | 115 | 19 | 24 | 88 | 32 | 38 | 140 | 544 | 148 | 9 |
| | Sine. | 22 | 69 | 16 | 20 | 49 | 178 | 107 | 36 | 165 | 195 | 524 | 553 | 8 | 311 | 340 | 369 | 368 | 727 | 756 | 185 | 814 | TIN |
| 3 Deg. | 002 | 0.059386 | 0526264 | 950 | 55 | 15. | 155 | 054 | 154 | 054 | 054 | 055 | 05 | 05 | 056 | 056 | 056 | 056 | 05 | 05 | 05 | 050 | Cosine. Cotan. |
| - | - | 10 | - | - 6 | | | 1 15 | | | | 5 | 0 | - | 67 | 3 | 4 | 5 | 9 | 7 | 00 | 6 | 0 | 1 |
| | 1 | | | | | | | | | | | - | - | - | - | - | - | - | - | - | - | CS. | - |

| | - | _ | | | | | | | - | _ | - | | | | | | | | | | | | | |
|--------|-----------------------|---|--|---|--|--|---|---|--|--|--|---|--|--|--|--|--|--|---|---|--|--|----------------------|-----|
| | - | 19 | 18 | 1 | 16 | 15 | E | 13 | 2 | - | 10 | 8 | 00 | 7 | 9 | 10 | 4 | 00 | 63 | = | 0 | | 1 | I |
| | Tang. Cctang. Cosine. | 9966612 19 | $0.700467 \cdot 0.70219 \cdot 14 \cdot 24113 \cdot 9975437 \cdot 5922 \cdot 0.761390 \cdot 0.76360 \cdot 13 \cdot 0.9575 \cdot 9970972 \cdot 13842 \cdot 0.819385 \cdot 0.82215 \cdot 1.816323 \cdot 0.966374 \cdot 0.96674 \cdot 0.9667$ | 12-12006-9966135 | 0825183 082800 12:07719 9965895 | $-0709171 \\ -071096 \\ 14-06545 \\ -9974822 \\ -997692 \\ -0770091 \\ -077238 \\ -077238 \\ -0970304 \\ -0$ | 46 0830981 083386 11 99234 9965414 | -0714974-071680 13-95071 -9974408 5427 -0775891 -077823 12-84955 -9969854 3347 -0833880 -083679 11-95037 -9965172 | ·078116 12·80141 ·9969628 32 48 ·0836778 ·083972 11·90868 ·9964929 | -078409 12-75363 -9969401 31 49 -0839677 -084265 11-86728 -9964685 | 12-70620 -9969173 30 50 -0842576 -084558 11-82616 -9964140 | -9964195 | -9963948 | -9963701 | -9963453 | 9963204 | -9962954 | 9962704 | -9962452 | 9962200 | -9961947 | | Sine. | |
| | Cctang. | 0697565 069926 14:30066 9975641 6021 0758489 076068 13:14612 9971193 3941 0816486 081922 12:20671 | 12-16323 | 12-12006 | 12-07719 | 12-03462 | 11-99234 | 11-95037 | 11-90868 | 11.86728 | 11.82616 | 2-65912 -9968945 2951 -0845474 -084851 11-78533 -9964195 | $-0729481 \cdot 073143 \cdot 13 \cdot 67185 \cdot 9973357 \cdot 4932 \cdot 0790391 \cdot 079287 \cdot 12 \cdot 61239 \cdot 9968715 \cdot 2852 \cdot 0848372 \cdot 086144 \cdot 11 \cdot 74477 \cdot 9963948 \cdot 07863648 \cdot 07868648 \cdot 0786864 \cdot 078666 \cdot 0786864 \cdot 0786664 \cdot 0786864 \cdot 0786664 \cdot 0786664 \cdot 078666 \cdot 0786666 \cdot 0786666 \cdot 0786666 \cdot 0786666 \cdot 0786666 \cdot 07866666$ | 2.0732382.073435 13-61740 9973145 4833 -0793290 079579 12.56589 9968485 2753 0851271 -085437 11-70450 -9963701 | 34 0796190 079872 12-51994 9968254 26 54 0854169 085730 11-66449 9963453 | -0738184 + 074020 $13.50979 + 9972717 + 46 35 + 0799090 + 080165 + 12.47422 + 9968022 25 55 + 0857067 + 086023 + 11.62476 + 9963204 + 996004 +$ | 56 -0859966 -086316 11-58529 -9962954 | $6.0743986.074605 \\ 13 + 40386 \\ 9972286 \\ 44 \\ 37 \\ 90804889 \\ 9080750 \\ 12 \cdot 38376 \\ 9967555 \\ 23 \\ 57 \\ 9967555 \\ 23 \\ 57 \\ 9962864 \\ 9868969 \\ 91 \\ 91 \\ 91 \\ 9962864 \\ 98689 \\ 91 \\ 98689 \\ 91 \\ 98689 \\ 91 \\ 91 \\ 91 \\ 92 \\ 92 \\ 93 \\ 92 \\ 93 \\ 93 \\ 94 \\ 94 \\ 94 \\ 94 \\ 94 \\ 94$ | -0746887:074897 [13-35151 -9972069] 4338 -0807788 -081043 [12-33902] -996732 [12258] -0865762 -086802 11-50715 -9962452 | $8 \cdot 0749787 \cdot 075190 \\ 13 \cdot 29957 \cdot 9971851 \\ 42 \\ 39 \cdot 0810687 \\ \cdot 0813651 \\ \cdot 0813661 \\ \cdot 0967085 \\ \cdot 2967085 \\ \cdot 2159 \cdot 0868666 \\ \cdot 0967085 \\ \cdot 087195 \\ \cdot 0868666 \\ \cdot 087195 \\ $ | 40 0813597 081629 12:25050 0906849 20 60 0871557 087488 11:43005 9961947 | | Tang. | |
| | Tang. | .081922 | -082215 | -082507 | -082800 | -083093 | -083386 | -083679 | -083972 | 084265 | -084558 | -084851 | -085144 | -085437 | -085730 | .086023 | -086316 | 609980- | -086902 | -087195 | 087488 | | Cotan. | |
| 4 Deg. | Sine. | 0816486 | 0819385 | 0822284 082507 | 0825183 | 0828082 | 1860280 | 0833880 | 0836778 | 0839677 | 0842576 | 0845474 | 0848372 | 0851271 | 0854169 | 0857067 | 0859966 | 0862864 | 0865762 | 0868660 | 0871557 | | Cosine. Cotan. Tang. | - |
| 4 | - | = | 52 | 13 | | 15 | 91 | 47 | 48 | 61 | 20 | 219 | 52 | 53 | 54 | 99 | 99 | 57 | 58 | 591 | 80 | | 1- | l |
| | - | 39 | 38 | 37 | 36 | 35 | 34 | 33 | 32 | 31 | 30 | 68 | 28 | 27 | 26 | 25 | 24 | 53 | 07 | 21 | 20 | | - | l, |
| | Cosine. | 9971193 | 9970972 | 9970750 | 9970528 | 9970304 | 0800266- | 9969854 | 8296966- | -9969401 | 9969173 | -9968945 | 9968715 | 9968485 | 9968254 | 2208966- | 9967789 | 9967555 | 9967321 | 9967085 | 9966849 | | Sine. | - |
| | Cotang. Cosine. | 13-14612 | 13-09575 | ·0703368 ·070511 14·18209 ·9975233 5823 ·0764290 ·076653 13.04576 ·9970750 3743 | $-0.706270 \cdot 0.70803 \cdot 14 \cdot 12353 \cdot 9975028 \cdot 5724 \cdot 0.767190 \cdot 0.76945 \cdot 12 \cdot 99616 \cdot 9970528 \cdot 3644 \cdot 124670 \cdot 124670$ | 12-94692 | ·0712073 ·071388 14·00785 ·9974615 5526 ·0772991 ·077531 12·89805 ·9970080 34 | 12.84955 | 12.80141 | 12-75363 | 12-70620 | 12-65912 | 12-61239 | 12-56599 | 12-51994 | 12-47422 | 5 -0741085 -074312 13-45662 -9972502 45 36 -0801989 -080458 12-42883 -9967789 24 | 12-38376 | 12-33902 | 12.29460 | 12-25050 | | Tang. | |
| | Tang. | 890920- | -076360 | -076653 | -076945 | -077238 | -077531 | -077823 | -078116 | -078409 | -078701 | -078994 | -079287 | 079579 | -079872 | 391080. | -080458 | 080750 | -081043 | -081336 | .081629 | | Cotan. | |
| 4 Deg. | Sine. | 0758489 | 0761390 | 0764290 | 0767190 | 1600220 | 1662770- | 0775891 | 1678770- | 1691840- | 0784591 | -0787491 | 0790391 | 0793290 | 0796190 | 0606620 | 0801989 | 0804889 | 9807788 | 0810687 | 0813587 | | , Cosine. | |
| 4 | - | 12 | 55 | 23 | 24 | 52 | 56 | 22 | 28 | 29 | 30 | 31 | 35 | 33 | 34 | 35 | 36 | 37 | 88 | 39 | 40 | | - | ı |
| | - | 09 | 59 | 58 | 57 | 56 | 55 | 54 | 53 | 52 | 51 | 50 | 49 | 48 | 47 | 46 | 45 | 44 | 43 | 42 | 41 | | ~ | |
| | Cosine, | -9975641 | -9975437 | -9975233 | -9975028 | -9974822 | -9974615 | .9974408 | -0717876 -071973 13-89404 -9974199 5328 -0778791 | 0720777 072265 13-83782 9973990 5229 0781691 | 0723678 072558 13-78206 9973780 51 30 0784591 078701 | 0 -0726580 -072850 13-72673 -9973569 50 31 -0787491 -078994 | -9973357 | -9973145 | 0735283 073727 13-56339 9972931 47 | -9972717 | -9972502 | -9972286 | -9972069 | -9971851 | 19-0752688 075482 13-24803 9971633 41 | 20 -0755589 -075775 13-19688 -9971413 40 | Sine. | 100 |
| | Cotang. | 14.30066 | 14-24113 | 14-18209 | 14-12353 | 14-06545 | 14-00785 | 13-95071 | 13.89404 | 13-83782 | 13-78206 | 13-72673 | 13-67185 | 13-61740 | 13-56339 | 13-50979 | 13-45662 | 13-40386 | 13-35151 | 13-29957 | 13-24803 | 13-19688 | Tang. | |
| | Tang. | -069926 | 012020 | 115070- | .070803 | 960120- | .071388 | -071680 | -071973 | 072265 | 072558 | -072850 | 073143 | 073435 | .073727 | -074020 | .074312 | -074605 | .074897 | -075190 | -075482 | -075775 | Cotan. | - |
| 1 Deg. | Sine. | -0697565 | -0700467 | -0703368 | -0706270 | -0709171 | -0712073 | -0714974 | -0717876 | -0720777 | -0723678 | 0726580 | -0729481 | -0732382 | -0735283 | -0738184 | -0741085 | -0743986 | -0746887 | -0749787 | 0752688 | -0755589 | Cosine. Cotan. | - |
| + | - ' | 0 | - | 03 | 2 | 4 | 0 | 9 | 1 | 00 | 6 | 10 | 11 | 12 | 13 | 14 | 15 | 91 | 17 | 18 | 19 | 30 | - | |
| | | | | | | | | | | | | | | | | | | | | | | | | |

| | | | | | | | - | | | , | | ï | | | - | - | , | | _ | | | | | - |
|---------|---|---|--|--|--|--|--|--|--|--|--|--|---|---|--|--|--|--|--|--|---|---------------------------------------|------------------------|---------|
| - | 1 | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 6 | 00 | 1 | 9 | 5 | 4 | 3 | C.S | = | 0 | | | 84 |
| Cosine. | 1 | $-0871557 - 087488 - 11 + 43005 - 9961947 \\ 60 \\ 21 - 0932395 - 093647 - 10 - 67834 - 9956437 \\ 39 \\ 41 - 0990303 - 099519 - 10 - 04828 - 9950844 \\ 19 \\ 41 - 0990303 - 0990303 - 0990303 \\ 41 - 0990303 - 0990303 - 0990303 - 0990303 \\ 41 - 0990303 - 0990303 - 0990303 - 0990303 \\ 41 - 0990303 - 0990303 - 0990303 - 0990303 - 0990303 \\ 41 - 0990303 - 0990303 - 0990303 - 0990303 - 0990303 - 0990303 \\ 41 - 0990303 - 0990300 - 0990000 - 099000 - 099000 - 099000 - 099000 - 099000 - 099000 - 099000 - $ | $11.39188 \cdot 9961693 \cdot 592 \cdot 0935291 \cdot 0935291 \cdot 093940 \cdot 10 \cdot 64499 \cdot 9956165 \cdot 3842 \cdot 0993197 \cdot 099813 \cdot 10 \cdot 01871 \cdot 9950556 \cdot 118671 \cdot$ | $-0877353 -088074 11\cdot 35397 -9961438 58 23 \cdot 0938187 -094234 10\cdot 61184 -9955892 3743 -0996092 -100107 9\cdot 989305 -9960266 -100107 $ | $\cdot 0880251 \cdot 088368 \cdot 11 \cdot 31630 \cdot 9961183 \cdot 5724 \cdot 0941083 \cdot 094527 \cdot 10 \cdot 57889 \cdot 9955620 \cdot 3644 \cdot 0998986 \cdot 100400 \cdot 9 \cdot 960072 \cdot 9949976 \cdot 100400 \cdot 1004000 \cdot 100400 \cdot 100400 \cdot 100400 \cdot 100400 \cdot 100400 \cdot 100400 \cdot 1004000 \cdot 100400 \cdot 100400 \cdot 100400 \cdot 100400 \cdot 100400 \cdot 100400 \cdot 1004000 \cdot 100400 \cdot 100400 \cdot 100400 \cdot 100400 \cdot 100400 \cdot 100400 \cdot 1004000 \cdot 100400 \cdot 100400 \cdot 100400 \cdot 100400 \cdot 100400 \cdot 100400 \cdot 1004000 \cdot 100400 \cdot 100400 \cdot 100400 \cdot 100400 \cdot 100400 \cdot 100400 \cdot 1004000 \cdot 100400 \cdot 100400 \cdot 100400 \cdot 1004000 \cdot 1004000 \cdot 100400 \cdot 100400 \cdot 100400 \cdot 1004000 \cdot 100400 \cdot 100400 \cdot 100400 \cdot 100400 \cdot 100$ | 10.54615 9955345 35 45 1001881 100694 9.931008 9949685 | $0886046 \cdot 088954 \cdot 11 \cdot 24171 \cdot 9960669 \cdot 5526 \cdot 0946875 \cdot 095114 \cdot 10 \cdot 51360 \cdot 9955076 \cdot 3446 \cdot 1004775 \cdot 100988 \cdot 9 \cdot 902112 \cdot 9949393 \cdot 100886 \cdot 100888 \cdot 10088$ | -9949101 | $0891840; 089540 11 \cdot 16808; 9960152 5328; 0952666; 095701 10 \cdot 44911; 9954517 32 18 \cdot 1010563 \cdot 101576 9 \cdot 844816 9 948807 9 \cdot 94911 9 \cdot 9498807 9 \cdot 948810 9 \cdot 948$ | $0894738 089834 11 \cdot 13163 \cdot 9959892 52 \cdot 29 \cdot 0955562 \cdot 095995 10 \cdot 41715 \cdot 9954240 3149 \cdot 1013457 \cdot 101870 9 \cdot 816414 \cdot 9948513 9 \cdot 8948513 9 \cdot 8948513$ | $9 \cdot 0897635 \cdot 090127 \cdot 11 \cdot 09541 \cdot 9959631 \cdot 51 \cdot 30 \cdot 0958458 \cdot 096289 \cdot 10 \cdot 38539 \cdot 9953962 \cdot 30 \cdot 50 \cdot 1016351 \cdot 102164 \cdot 9 \cdot 788173 \cdot 9948217 \cdot 30 \cdot 100 \cdot$ | -9947921 | $.0903429 \cdot 090713 \cdot 11.02367 \cdot 9959107 \cdot 4932 \cdot 0964248 \cdot 096876 \cdot 10.32244 \cdot 9953403 \cdot 2852 \cdot 1022138 \cdot 102752 \cdot 9.732171 \cdot 9947625 \cdot 100000000000000000000000000000000000$ | 9947327 | -0909223 + 091300 + 10 - 95285 + 9958580 + 7734 + 0970039 + 097463 + 0.26024 + 9952840 + 2654 + 1027925 + 103339 + 9676800 + 9947028 + 9952840 + | $\cdot 0912119 \cdot 091593 \cdot 10 \cdot 91777 \cdot 9958315 \cdot 4635 \cdot 0972934 \cdot 097757 \cdot 10 \cdot 22942 \cdot 9952557 \cdot 2555 \cdot 1030819 \cdot 103634 \cdot 9 \cdot 649347 \cdot 9946729 \cdot 103634 \cdot 10364 \cdot 10$ | $.0915016 \cdot 091887 \cdot 10 \cdot 88292 \cdot 9958049 \cdot 45 \cdot 36 \cdot 0975829 \cdot 098050 \cdot 10 \cdot 19878 \cdot 9952274 \cdot 24 \cdot 56 \cdot 1033712 \cdot 103928 \cdot 9 \cdot 622048 \cdot 9946428 \cdot 1091887 \cdot 109187 \cdot 10918$ | $.0917913 \cdot 092180 \cdot 10 \cdot 84828 \cdot 9957783 \cdot 44 \cdot 37 \cdot 0978724 \cdot 098344 \cdot 10 \cdot 16833 \cdot 9951990 \cdot 2357 \cdot 1036605 \cdot 104222 \cdot 9 \cdot 594902 \cdot 9946127 \cdot 104000 \cdot 1040000 \cdot 104000 \cdot 1040000 \cdot 10400$ | $-0920809 \cdot 092473 \cdot 10 \cdot 81387 \cdot 9957515 \cdot 4238 \cdot 0981619 \cdot 098638 \cdot 10 \cdot 13805 \cdot 9951705 \cdot 2258 \cdot 1039499 \cdot 104516 \cdot 9 \cdot 567906 \cdot 9945825 \cdot 109208 \cdot 108808 \cdot 1088$ | $.0923706 \cdot 092767 \cdot 10 \cdot 17967 \cdot 9957247 \cdot 4239 \cdot 0984514 \cdot 098932 \cdot 10 \cdot 10795 \cdot 9951419 \cdot 2159 \cdot 1042392 \cdot 1042810 \cdot 9 \cdot 541061 \cdot 9945523 \cdot 1042392 \cdot 10$ | $19.0926602\cdot093060\ 10.74568\cdot9956978\ 41\ 40\cdot0987408\cdot099225\ 10.07803\cdot9951132\ 20 60\cdot1045285\cdot105104\ 9\cdot514364\cdot9945219 $ | | Sine. | Deg. 84 |
| Cotang. | , | 10.04828 | 10.01871 | 9-989305 | 9-960072 | 9-931008 | 9-902112 | 9-873382 | 9.844816 | 9.816414 | 9-788173 | 9-760092 | 9-732171 | 9-704407 | 008949-6 | 9-649347 | 9.622048 | 9-594902 | 9.567906 | 9.541061 | 9.514364 | | Tang. | |
| Tang. | 1 | -099519 | .099813 | 100107 | 100400 | 100694 | 100988 | 101282 | 101576 | 101870 | 102164 | 102458 | 102752 | 103046 | 103339 | 103634 | 103928 | 104222 | 104516 | 104810 | 102104 | | Cotan. | |
| Sine. | 1 | 0990303 | 0993197 | 0996092 | 9868660 | 1001881 | 1004775 | 1007669 | 1010563 | 1013457 | 1016351 | 1019245 | 1022138 | 1025032 | 1027925 | 1030819 | 1033712 | 1036605 | 1039499 | 1042392 | 1045285 | | Cosine. Cotan. | |
| IS I | i | 411 | 42 | 43 | 44 | 45 | 46 | 47 | 18 | 49 | 20 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 28 | 59 | 09 | | | |
| - | 1 | 39 | 38 | 37 | 36 | 35 | 34 | 33 | 35 | 31 | 30 | \$ 29 | 3 28 | 3 27 | 26 | 25 | 1 24 | 23 | 5 22 | 121 | 20 | Ш | - | Dog 84 |
| Cosine. | - | -9956437 | 9956165 | -9955892 | -995562 | -9955348 | 9955070 | 9954794 | 9954517 | -995424(| -9953965 | -9953685 | 9953408 | -9953129 | -995284(| -9952557 | 9952274 | -995199(| -995170 | -9951418 | 9951135 | | Sine. | De |
| Cotang. | 0 | 10.67834 | 10-64499 | 10.61184 | 10.57889 | 10-54615 | 10-51360 | 10.48126 | 10-44911 | 10-41715 | 10-38539 | 10-35382 | 10-32244 | 10-29125 | 10-26024 | 10.22942 | 10-19878 | 10-16833 | 10-13805 | 10-10795 | 10.07803 | | Tang. | |
| Tang. | | .093647 | 093940 | 094234 | -094527 | .094821 | 095114 | -095408 | .095701 | -095995 | .096289 | -096582 | 928960 | 691160 | 097463 | -097757 | 098020 | 098344 | -098638 | -098932 | -099225 | | Cotan. | |
| / Sine. | | 0932395 | 1632260- | 0938187 | -0941083 | 11.27888 -9960926 56 25 -0943979 -094821 | 0946875 | $0888943 \cdot 089247 \cdot 11 \cdot 20478 \cdot 9960411 \cdot 5427 \cdot 0949771 \cdot 095408 \cdot 10 \cdot 48126 \cdot 9954794 \cdot 3347 \cdot 1007669 \cdot 101282 \cdot 9949101$ | -0952666 | -0955562 | -0958458 | $0.0900532 \cdot 090420 \cdot 11.05943 \cdot 9959370 \cdot 50 \cdot 31 \cdot 0961353 \cdot 096582 \cdot 10.35382 \cdot 9953683 \cdot 2951 \cdot 1019245 \cdot 102458 \cdot 9.760092 \cdot 9947921 \cdot 10000000000000000000000000000000000$ | .0964248 | $2.0906326 \cdot 091007 \cdot 10 \cdot 98815 \cdot 9958844 \cdot 48 \cdot 33 \cdot 0967144 \cdot 097169 \cdot 10 \cdot 29125 \cdot 9953122 \cdot 2753 \cdot 1025032 \cdot 103046 \cdot 9 \cdot 704407 \cdot 9947327 \cdot 100000000000000000000000000000000000$ | -0970039 | 0972934 | 0975829 | -0978724 | 6191860 | -0984514 | 0987408 | | Cosme. Cotan. | 1 |
| E | | 21 | 22 | 23 | 24 | 25 | 56 | 27 | 28 | 53 | 30 | 31 | 35 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | | - | |
| - | _ | 2 60 | 3 59 | 8 58 | 3 57 | 3 56 | 3 55 | 54 | 2 53 | 2 52 | 151 | 50 | 49 | 48 | 47 | 5 46 | 145 | 3 44 | 5 43 | 7 42 | 941 | 3 40 | - | P.S. |
| Cosine. | | 9961947 | -9961695 | -9961438 | 811966. | -9960926 | 990966 | 9960411 | -996015 | .9959895 | -9959631 | -995937(| -9959107 | -9958844 | -995858(| 995831 | -995804 | 995778 | 995751 | -9957247 | -9956978 | -9956708 | Sine. | Dec 84 |
| Cotang. | 0 | 11-43005 | 11.39188 | 11-35397 | 11-31630 | 11-27888 | 11-24171 | 11.20478 | 11.16808 | 11-13163 | 11-09541 | 11-05943 | 11-02367 | 0.98815 | 10-95285 | 7777 | 10-88292 | 0.84828 | 10-81387 | 19671-01 | 10-74568 | 10-71191 | Tang. | - |
| Tang. | _ | 087488 | 087781 | 088074 | 898880 | 199880 | 088954 | 089247 | 089540 | 089834 | -090127 | 090420 | .090713 | -091007 | -091300 | -091593 | 1 188160- | 092180 | 092473 | 1092767 | 093060 | -093354 | Cotan. | |
| Sine. | | 0871557 | 0874455 087781 | 0877353 | 0880251 | 0883148 088661 | 0886046 | 0888943 | 0891840 | 0894738 | 0897635 | 0900532 | 0903429 | 9289060 | 0909223 | 0912119 | 0915016 | 0917913 | 0920809 | 0923706 | 2099260 | 20 0929499 093354 10.71191 9956708 40 | Cosine. Cotan. Tang. | 1 |
| - | | 0 | - | 65 | | + | 5 | 8 | 1 | 00 | 6 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 50 | (- | 1 |

| - | _ | - | - | - | - | - | - | - | _ | _ | _ | _ | | _ | - | - | - | | | _ | - | - |
|--------|---------|-------------------------|--|--|------------------------------------|---|-----------------------------------|--------------------------------|---------------------------------|---|--|---|--------------------------------------|---|---|--|---|---|--|--|---|--------------------|
| 1 | - 1 | = | 7 | - | = 1 | - | - | - | = | = | - | - | | | | | | | | | 1 | - |
| 1 | Cosine, | .0032045 | 0031706 | 10031307 | 9801866 | 08908080 | 7 7 | 9959699 | 0100500 | 0008000 | 9108800- | 9028271 | 002200 | 0000000 | \$682866 | STREET, | 1800800 | COLOSCO. | OTHORSON. | The state of the s | | Bine. |
| | Cotang | 8-534017 | 8-012594 | 8-401277 | 8-470065 | 8-448907 | 8427903 | 8-380261 | 8-303653 | 19832 8-344955 | 8-024467 | 8-304008 | 20718 8-283707 | 21013 8-263554 | 21308 8:2434 18 | S0000000 | | B-183704 | 21 50 12 15 500 12 22 40 M 10 10 10 10 10 10 10 10 10 10 10 10 10 | 0.000. | - | Tang. |
| | Tang. | 117178 | 5444TT | = | 18062 | 118387 | 118602 | 84046 -119249 8-38025 | 86928 -119837 8-303658 | = | 120127 | 120423 | = | 7 | = : | 121603 | 121698 | 1001001 | 122460 | solen. | - | Cotan. |
| 6 Deg. | Sine. | 1163818 | 1166707 | 1169596 | - | - | 1178263 | 1184040 | 1186928 | 1189816 | 1192704 | 1195593 | 1198481 | | | 1207144 | | 0102121 | 1215806 | 0000121 | 1 | ' Cosine. Cotan. |
| 9 | - | = | 22 | 2 | 3 | 9 | 9 1 | 2 | 10 | 20 | 91 | 23 | 23 | 20 | 00 | 90 | 20 | 90 | 000 | 00 | 1 | |
| -1 | | 30 | 38 | 33 | 3 | 98 | 900 | 9 60 | 3.1 | 30 | 25 | 100 | 27 | | | 200 | 20 0 | 58 c | 20 0 | 2 | | * |
| | Cosine. | 9938648 | 9938326 | 9938003 | 9937679 | 9937305 | 9937029 | | 9936047 | 9935719 | -9935389 29 | 4525 8-731719 -9935058 28 | 4819 8-709307 -9934727 27 | 8-687008 -9934395 26 | 9934062 | 9933728 | 5998 8-620783 -9983393 23 | 6203 8-598929 -9933057 22 58 - | 1828866 | .002228 | İ | Sine. |
| | Cotang. | 8-985984 | 8.962266 | 8-938672 | 24 1114689 112168 8 915200 9937679 | 8-891880 | 20471 112757 8.868620 9937029 | 13346.8-822518 -9936375 | 3641 8-799644 -9936047 | 3935 8-776887 9935719 | 4230 8-754246 | 8-731719 | 8-709307 | 8.687008 | 15409 8-664822 -9934062 | 8-642747 | 8-620783 | 8-208020 | 8.577183 | 40-1160929-116883 8-055546 -093288 | 1 | Tang. |
| | Tang. | 106017-111284 | 111678 | 111873 | -112168 | 112462 | 112757 | - | - | | = | 114625 | 114819 | 15114 | 115409 | 115703 | 115998 | .116293 | 116588 | 116883 | - | Cotan. |
| 6 Deg. | Sine. | 1108017 | 1108908 | 1111799 | 1114689 | 1117580 | 1120471 | 119695911 | | 1132032 1 | 1134992 | 1137812 | 1140702 | 1143592 | 1146482 | 1149372 | 1162261 | 1155151 | 1158040 | 1160929 | - | ' Cosine. Cotan. |
| B | - | 15 | 57 | 53 | 10 | 52 | 98 | - 0 | 62 | 30 | 31 | 22 | 33 | 77 | 32 | 36 | 2 | 38 | 30 | 9 | 1 | - |
| | | 09 | 28 | 99 | 57 | 56 | 26 | 50 | 55 | 51 | 50 | 61 | 8 | 5 | 91 | 12 | 2 | 63 | 53 | | | - |
| | Cosine. | -9945219 6021 | 105398 9-487814 -9944914 59 22 -1108908 -111578 8-962266 | -9944609 58 23 -1111799 -111873 8-938672 | 05986 9-435153 -9944303 57 | 106280 9-409038 9943996 56 25 -1117580 -112462 8-891850 9937355 | 06575 9.383066 .9943688 55 26 .11 | 06869 9:357235 3943379 54 27 1 | 07457 9-305993 -9942760 5229 -1 | 071318 -107751 9-280580 -9942448 51 30 -1 | 08046 9-255303 -9942136 50 31 -1134922 | 1077102 108340 9-230162 9941823 49 32 1 | 08634 9-205156 9941510 48 33 1140702 | 082885 -108929 9-180283 -9941195 4734 -1143592 -1 | 09223 9-155543 -9940880 46 35 -1146482 -1 | 088669 -109517 9-130934 -9940563 45 36 -1149372 -115703 8-642747 -9933728 34 | 091560 -109812 9-106456 -9940246 44 37 -1152261 -11 | 094452 -110106 9-082107 -9939928 43 38 -1155151 -11 | 097343 110401 9-057886 9939610 42 39 1158040 116588 8 577183 9932731 | 19 -1100234 -110695 9-033793 -9939290 41 20 -1103126 -110989 9-009826 -9938969 40 | | Sine. |
| | Cotang. | 045285 -105104 9-514864 | 9-487814 | 05692 9-461411 | 9-435153 | 9-409038 | 9-383066 | 9-35/235 | 9-305993 | 9.280580 | 9-255303 | 9-230162 | 9-205156 | 9-180283 | 9-155543 | 9-130934 | 9.106456 | 9-082107 | 9-057886 | 9-033793 | | Tang. |
| | Tang. | 105104 | 105398 | - | 105986 | 106280 | -106575 | 106869 | 107457 | 107751 | 108046 | -108340 | .108634 | 108929 | .109223 | 109517 | -109812 | 110106 | 110401 | 110989 | | Cotan. |
| 5 Deg. | Sine. | 1045285 | 1048178 | 1051070 | 1053963 | 1056856 | 1059748 | 1062641 -1 | 1068425 | 1071318 | 1074210 | 1077102 | 1079994 | 1082885 | 1. 1777801- | | 10912601 | 1094452 | 1097343 | 1100234 | - | Cosine. Cotan. |
| 6 I | - | 10 | - | C. | 60 | * | 9 | 0 1 | - 00 | 6 | .01 | - | 12 | 131. | 14 | 1.91 | 91 | 17 | 18 | 91 | 1 | - |
| 1 | - | 1 | - | | - | - | - | | - | | - | _ | - | - | - | - | - | - | - | - 3, | - | - |

Deg. 83.

Deg. 83

| | TRIBLII | 01 011 | , , | 12110 | 111110, | 13.0. | 101 |
|---------|--|--|---|--|--|--|--------------------|
| - | 181 | 5 4 5 5 | 11.0 | 200 | 6044 | 0-10 | - 8 |
| Cosine. | 9910221 9909832 9909442 | .9908659 .9908266 .9907873 | 9907083 | .9906290 .9905893 .9905494 | -9905095 -9904694 -9904297 | 9903489 9903085 9902681 | Sine. ' Deg. 82 |
| Cotang. | 7-412397 7-396159 7-379990 | 7.353891 7.347861 7.331898 7.316004 7.300178 | 7-284418 | 7-253098 7-237537 7-222042 | 7.206611 7.191245 7.175943 | 7-145530 7-130419 7-115369 | Tang. |
| Tang. | 134909 135205 135501 | 135797 136094 136390 136686 | 137279 | 137872 138168 138465 | 139761 139958 139354 | 139947 -140244 -140540 | Cotan. |
| Sine. | -1336979 -1339862 -1342744 | -1345627 -1348509 -1351392 -1354274 | 1360038 | -1365801 -1368683 -1371564 | -1374445 -1377327 -1380208 | 1385970 13885970 1391731 | 1/ Cosine. |
| - | 3941 3842 3743 | 35 45 35 45 34 46 32 47 | 31 19 | 29 51 28 52 27 53 | 26 54 25 55 24 56 | 22.58 21.59 20.60 | |
| Cosine, | 9917832 9917459 9917086 | -9916712 -9915337 -9915961 -9915584 | 9914828 | -9914069 -9913688 -9913306 | 9912923 | 9911384 9910997 9910610 | Sine. |
| Cotang. | 7-752536 7-734802 7-717148 | 7-699573 7-682076 7-664658 7-647317 7-630053 | 7-612865 | 7-578717 7-561756 7-544869 | 7-528057 7-511317 7-494651 | 7-461535 7-445085 7-428706 | Tang. |
| Tang. | -128990 -129285 -129581 | 129877 130173 130469 130764 | 131356 | -131948 -132244 -132540 | 132836 | 134612 -134612 | Cotan. |
| Sine. | -1279302 -1282186 -1285071 | 1290841 1290841 1293725 1296609 | 1302378 | -1308146 -1311030 -1313913 | 1316797 | 1328330 1331213 1334096 | / / Cosine. Cotan. |
| - | 0 21 0 22 8 23 8 23 | 625 4 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 | 2 29 | 031 932 833 | 734 635 536 | 2338 140 0 140 | |
| Cosine. | $\frac{0.1218693}{1.22784} \cdot \frac{122784}{8.144346} \cdot \frac{9925462}{9925407} \cdot \frac{6021}{1.279302} \cdot \frac{128990}{12928} \cdot \frac{7752536}{7734802} \cdot \frac{9917459}{991708} \cdot \frac{9941}{1339862} \cdot \frac{134999}{135201} \cdot \frac{79910221}{7979990} \cdot \frac{9909832}{7724468} \cdot \frac{123375}{123375} \cdot \frac{8.105359}{8105359} \cdot \frac{9924751}{9924751} \cdot \frac{189581}{5823} \cdot \frac{7717148}{129581} \cdot \frac{9917086}{7717148} \cdot \frac{9917086}{991708} \cdot \frac{37474}{135501} \cdot \frac{779990}{779990} \cdot \frac{9909442}{7000050442} \cdot \frac{123375}{123375} \cdot \frac{123775}{123375} \cdot \frac{123775}{12375} \cdot \frac{123775}{123375} \cdot $ | $\begin{array}{c} 122.7355 \ \ 123670 \ \ 8 \cdot 086004 \ \ \ 9924394 \ \ \ \ 5724 \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \$ | $\frac{241788 \cdot 12514777990575 \cdot 9922599}{244674 \cdot 1254427 \cdot 7971755 \cdot 99222377} = 13 \cdot 13 \cdot 13 \cdot 15 \cdot 17 \cdot 12 \cdot 12 \cdot 12 \cdot 12 \cdot 12 \cdot 12 \cdot 12$ | $\begin{array}{c} 0.1247560.125738 7\cdot953022 9921874 50[31].1308146 1\cdot31948 7\cdot578717 9914069 2957 1\cdot365801\cdot137872 7\cdot253098 9906290\\ 11\cdot1250446 -126933 7\cdot934375 9921511 49[32\cdot1311030\cdot132244 7\cdot561756\cdot 9913688]28[52\cdot1368683\cdot138168 7\cdot237537 9905893\\ 2\cdot253332\cdot 126329 7\cdot915815\cdot 9921147 48[33\cdot133913\cdot132540]7\cdot544869\cdot 9913306[2753\cdot1371564\cdot138465]7\cdot222042\cdot 9905494 \end{array}$ | $\begin{array}{c} 3.1256218.126624 \ 7.897339 \ 9920782 \ 47 34 \ 11316797 \ 1132886 \ 7.528057 \ 9912923 \ 2654 \ 11377327 \ 1139058 \ 7.91245 \ 9904699 \ 47.259104 \ 11259104 \ 11259104 \ 11259104 \ 11259104 \ 11259104 \ 11259104 \ 11259104 \ 11259104 \ 11259104 \ 11259104 \ 11259104 \ 11259104 \ 11255540 \ 1125540 \ 11255540 $ | $ \begin{array}{c} 10.1264875 \cdot 127111 \cdot 79242719 \cdot 9919052 \cdot 4447 \cdot 1732794 \cdot 1732794 \cdot 174553 \cdot 19919314 \cdot 174553 \cdot 17453 | Sine. |
| Cotang. | 8-144346 8-124807 8-105359 | 8-086004 8-066739 8-047564 8-028479 8-028479 | 7-990575 | 7-953022 7-934375 7-915815 | 7-897339 7-878948 7-860642 | 7-824279 7-824279 7-806221 7-788245 7-770350 | Tang. |
| Tang. | -122784 -123079 -123375 | 1236570 123965 124261 124556 | 125147 | 125738 126333 | 126624 126920 127216 | 127807 128103 128398 128694 | Cotan. |
| Sine. | 1218693 1221581 1224468 | 1237355 123670 1230241 123965 1233128 124261 1236015 124556 | 1241788 | -1247560 -1250446 -1253332 | 1256218 1259104 1261990 | 1264875 1267761 1270646 1273531 1276416 | Cosine. |
| - | 10-00 | 84605 | - 00 00 | 110 | 13 | 2000 | [-] |

| | 3 | 20 1 | 23 | 9 | 2 | 2 | 23 | 2 | = | 9 | 0 | æ | 2 | ø | 0 | Ŧ. | 9 | CH | - | 0 | | - |
|-----------------------|---------------------------------------|--|--|------------------------------------|--|--|--|--|---|--------------------------------------|---|---|--|---------------------------------------|--|---|--|--|--|---|---------------------------------------|----------------|
| Coeme. | 9885378 | 9884939 | 9884498 | 9884057 | 0198886 | 9883172 | 9885758 | 9882284 | 9881886 | 9881398 | 9880945 | 9880497 | 9880048 | 9879599 | 9879148 | 9878697 | 9878245 | 9877780 | 98773381 | 9870883 | | Sine. |
| Tang. Cotang. | 6-547767 -9885378 | 6261886-650989-9 | 6-5223391-9884498 | 6.509698 988405 | 6-497104 | 6484558 4883172 | 8-472059 9882728 | 6-459607 | 6-447201 -988183 | 6-434842 | 6-422530 -988094 | 541356 155999 6-410263 9880497 | 6-398042 | 56595 6-385866 - | 6-373736 -987914 | 6-361650 | 57490 6-349609 -987824 | 6-337612 -0877799 | 59 1561472 158086 6-325660 9877338 | 500857 -152426 6-560558 -9885817 20 60 -1564345 -158384 6-313751 -9876883 | | Tang. |
| Tang. | -152723 | | | | -153914 | 154212 | -154510 | 154808 | 532733 -155106 | 155404 | 105521 | 155999 | 156297 | 156595 | 156893 | 167191 | | 157788 | 158086 | 158384 | | Count. |
| Sine- | 1509733 -1 | 1512608-1 | 1515484 | 1518359 | 1521234-1 | 1524109 1 | 1526984 -1 | 1529858 | 1532733 | 1535607 1 | 1538482 1 | | 1544230 -1 | 1547104-1 | 1549978 | 1552851 | 57 -1555725 -1 | 58 -1558598 - | 1561472 | 1564345 | | Cosine. |
| , | = | 27 | 433 | 44 | 45 | 46 | 4.7 | 48 | 49 | 50 | 51 | 52 | 63 | 54 | 92 | 56 | 57 | 58 | 69 | 00 | | - |
| - | 39 | 38 | 37 | 36 | 35 | 34 | 33 | 32 | 3 | 30 | 68 | 38 | 27 | 26 | 25 | 200 | 23 | 900 | | 20 | | - |
| Cosine. | 9893994 | 9893572 | 9893148 | 9892723 | 9892298 | 9891872 | 9891445 | 9891017 | 9890588 | 9890159 | 9889728 | 9889297 | 9888869 | 9888432 | 9887998 | 9887564 | 9887128 | 9886692 | 9886255 | 9885817 | | Sine. |
| Tang. Cotang. Cosine. | 452197 -146775 6-813122 -9893994 3941 | 3-799356 | 3-785644 | 1460830 147667 6-771986 9892723 36 | 3-758382 | 6-744831 -9891872 34 | 5-731334 | 472340 -148856 6-717889 -9891017 3248 | 475217 149153 6-704496 9890588 31 | 1478094 -149451 6-691156 -9890159 30 | 80971 -149748 6-677867 -9889728 29 | 1483848 150045 6-664630 9889297 28 52,- | 86724 -150343 6-651444 -9888865 27 | 489601 -150640 6-638310 -9888432 26 | 492477 - 150938 6-625225 - 9887998 25 | 495353 151235 6-612191 9887564 24 | 498230 -151533 6-599208 -9887128 23 | 501106 151830 6-586273 9886692 22 | 8-573389 | 8-560558 | | Tang. |
| Tang. | 146775 | 147072 | 147369 | 147667 | 147964 | 148261 | 148559 | 148856 | 149153 | 149451 | 149748 | 150045 | 150343 | 150640 | 150938 | 151235 | 151533 | 151830 | 152128 | 152426 | | Cotan. |
| Sine. | 1452197 | 1455075 | 1457953 | 1460830 | 1463708 | 1466585 -148261 | 1469463 | 1472340 | 1475217 | 1478094 | 1480971 | 1483848 | Ξ | 1489601 | | | | | 1503981 | 1506857 | | Cosine, Cotan. |
| 4 | == | 55 | 533 | 24.1 | 55 | 26 | 27 | 88 | 68 | 30 -1 | 01 | 32 | 33 | 34 | 35 | 36 | 37 | 88 | 39 | 40 -1 | | 1- |
| 4 | 1-1209 | 59 | 28 | 57 | 56 | 55 | 54 | 53 | 52 | 51 | 50 | 49 | 48 | 47 | 46 | 45 | 44 | 43 | 12 | 41 | 40 | 1 |
| Cosine. | 1892066- | -1394612 -140837 7-100382 -9902275 5922 -1455075 -147072 6-799356 -9893572 3842 -1 | 397492 141134 7-085457 9901869 5823 1457958 147369 6-785644 9893148 3743 1 | 1400372 141430 7-070593 9901462 57 | 1403252 141727 7-055790 -9901055 56 25 1463708 147964 6-758382 -9892298 35 | 1406132 142024 7-041048 9900646 5526 1 | $\cdot 1409012 \cdot 142321 \cdot 7026366 \cdot 9900237 \cdot 5427 \cdot 1469463 \cdot 148559 \cdot 6 \cdot 731334 \cdot 9891445 \cdot 3347 \cdot 70000000000000000000000000000000000$ | 1411892 142617 7-011744 9899826 5328 1 | 8 1414772 142914 6-997180 9899415 52 29 1 | 1417651 143211 6-982678 9899003 51 | 0 1420531 143508 6-968233 9898590 50 51 | 1 -1423410 -143805 6-953847 -9898177 49,32 -1 | 2 1426289 144102 6-939519 9897762 4833 | 13 1429168 144399 6 925248 9897347 47 | 1432047 144696 6-911035 9896931 4635 1 | 5 1434926 144993 6-896879 9896514 45 36 1 | 6 -1437805 -145290 6-882780 -9896096 44 37 - | 440684 145587 6-868737 9895677143 38 1 | 8 1443562 145884 6 854750 9895258 42 39 1503981 152128 6 573389 9886255 21 | 6-840819 -9894838 41 | 20 1449319 146478 6.826943 9894416 40 | Sine. |
| Cotang. Cosine. | 1391731 -140540 7-115369 -9902681 | 7-100382 | 7-085457 | 7-070593 | 7-055790 | 7-041048 | 7-026366 | 7-011744 | 6-997180 | 6.982678 | 6-968233 | 6-953847 | 6-939519 | 6.925248 | 6.911035 | 6.896879 | 6.882780 | 6-868737 | 6-854750 | 6.840819 | 6-826943 | Tang. |
| Tang. | 140540 | -140837 | 141134 | 141430 | 141727 | .142024 | .142321 | 142617 | 142914 | 143211 | .143508 | -143805 | -144102 | .144399 | .144696 | .144993 | .145290 | 145587 | 145884 | 146181 | .146478 | Cotan. |
| Sine. | 1391731 | 1394612 | 1397492 | 1400372 | 1403252 | 1406132 | 1409012 | 1411892 | 1414772 | 1417651 | 1420531 | 1423410 | 1426289 | 1429168 | 1432047 | 1434926 | 1437805 | 1440684 | 1443562 | 19-1446440 -146181 | 1449319 | Cosine. |
| | | | | | | | | | | | | | | | | | | | | | | |

| - | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 6 | 80 | 7 | 9 | 5 | 4 | 3 | 63 | - | 0 | | - |
|---------|--|--|--|--|--|--|--|--|--|---|---|--|--|--|--|--|---|--|--|--|--|----------------|
| Cosine. | 9857524 | 9857035 | 9856544 | 9856053 | 9855561 | 8909986 | 9854574 | 9854079 | 9853583 | 9853087 | 9852590 | 9852092 | 9851593 | 9851093 | 9850593 | 9850091 | 9849589 | 9849086 | 9848582 | 9848078 | | Sine. |
| Cotang. | 0.1561345 .158384 6.313751 -9876883 6021 .1624650 .164652 6.073397 .9867143 3941 .1682026 .170633 5.860505 .9857524 19 | $[567218] \cdot 158682 \cdot [6\cdot301886] \cdot 9876428 \cdot [5976428] \cdot [597520] \cdot [64951 \cdot [6\cdot062396] \cdot 9866670 \cdot [3842] \cdot [1684894] \cdot 170933 \cdot [5\cdot80241] \cdot 9857035 \cdot [1884894] \cdot [18848] \cdot [1884894] \cdot [1884894] \cdot [1884894] \cdot [1884894] \cdot [1884894] \cdot $ | $-570091 \cdot 158980 \cdot 6\cdot 290065 \cdot 9875972 \cdot 5823 \cdot 1630390 \cdot 165250 \cdot 6\cdot 051434 \cdot 9866196 \cdot 3743 \cdot 1687761 \cdot 171232 \cdot 5\cdot 840011 \cdot 9856544 \cdot 1866664 \cdot 1866666 \cdot 186666 \cdot 1866666 \cdot 1866666 \cdot 1866666 \cdot 1866666 \cdot 1866666 \cdot 1866666 \cdot 186666 \cdot 1866666 \cdot 18666666 \cdot 1866666 | $572963 \cdot 159279 \cdot 6 \cdot 278286 \cdot 9875514 \cdot 5724 \cdot 1633260 \cdot 165548 \cdot 6 \cdot 040510 \cdot 9865722 \cdot 36144 \cdot 1690628 \cdot 171532 \cdot 5 \cdot 829817 \cdot 9856053 \cdot 1660628 \cdot 171532 \cdot 171523 \cdot 171523 \cdot 1715$ | $575836 \cdot 159577 \cdot 6 \cdot 26551 \cdot 9875057 \cdot 5625 \cdot 1636129 \cdot 165847 \cdot 6 \cdot 029624 \cdot 9865246 \cdot 35145 \cdot 1693495 \cdot 171831 \cdot 5 \cdot 819657 \cdot 9855561$ | $578708 \cdot 159875 \cdot 6 \cdot 254858 \cdot 9874598 \cdot 5526 \cdot 1638999 \cdot 166146 \cdot 6 \cdot 018777 \cdot 9864770 \cdot 34 \cdot 16 \cdot 1696362 \cdot 172130 \cdot 5 \cdot 809531 \cdot 9855068 \cdot 32 \cdot 123130 \cdot 123130 | $\cdot 1581581 \cdot 160174 \cdot 6 \cdot 243208 \cdot 9974138 \cdot 54 \cdot 27 \cdot 1641868 \cdot 166445 \cdot 6 \cdot 007967 \cdot 9864293 \cdot 3347 \cdot 1699228 \cdot 172430 \cdot 5799440 \cdot 9854574 \cdot 1699228 \cdot 172430 \cdot 172430 \cdot 179440 \cdot 9854574 \cdot 1784186 \cdot 17841$ | $\cdot 1584453 \cdot 160472 \cdot 6 \cdot 231600 \cdot 9873678 \cdot 5328 \cdot 1644738 \cdot 166744 \cdot 5 \cdot 997195 \cdot 9863815 \cdot 32 \cdot 181 \cdot 1702095 \cdot 172730 \cdot 5 \cdot 789382 \cdot 9854079 \cdot 122730 \cdot$ | $-587325 - 160770 - 6 \cdot 220034 - 9873216 - 52229 - 1647607 \cdot 167043 - 5 \cdot 986461 - 9863336 - 3149 - 1704961 \cdot 173029 \cdot 5 \cdot 779358 - 9853583 - 180770 - 1807$ | $9 \cdot 1599197 \cdot 161069 \cdot 6 \cdot 208510 \cdot 9872754 \cdot 51 \cdot 30 \cdot 1650476 \cdot 167342 \cdot 5 \cdot 975764 \cdot 9862856 \cdot 30 \cdot 1707828 \cdot 173329 \cdot 5 \cdot 769368 \cdot 9853087 \cdot 100000000000000000000000000000000000$ | $0.1593069 \cdot 161367 \cdot 6 \cdot 197027 \cdot 9872291 \cdot 50 \cdot 31 \cdot 1653345 \cdot 167641 \cdot 5965104 \cdot 9862375 \cdot 2951 \cdot 1710694 \cdot 173628 \cdot 5 \cdot 759412 \cdot 9852590 \cdot 10000000000000000000000000000000000$ | $.595940 \cdot 161666 \cdot 185586 \cdot 9871827 \cdot 49 \cdot 13266214 \cdot 167940 \cdot 167940 \cdot 167948 \cdot 19861894 \cdot 12852 \cdot 1713560 \cdot 173928 \cdot 16749488 \cdot 19852092 \cdot 167898 \cdot 1113560 \cdot 111360 \cdot 111$ | $12 \cdot 1598812 \cdot 161964 \cdot 6 \cdot 174186 \cdot 9871363 \cdot 4833 \cdot 1659082 \cdot 168239 \cdot 5 \cdot 943895 \cdot 9861412 \cdot 2753 \cdot 1716426 \cdot 174228 \cdot 5 \cdot 739598 \cdot 9851593 \cdot 1716426 \cdot 174228 \cdot 1716426 \cdot 174228 \cdot 1716426 \cdot 174228 \cdot 1716426 \cdot 17$ | $3 \cdot 1601683 \cdot 162263 \cdot 6 \cdot 162827 \cdot 9870897 \cdot 47 \cdot 34 \cdot 1661951 \cdot 168539 \cdot 5 \cdot 933345 \cdot 9860929 \cdot 2654 \cdot 1719291 \cdot 174527 \cdot 5 \cdot 729741 \cdot 9851093 \cdot 168888 \cdot 16888 \cdot 168888 \cdot 16888 \cdot 168888 \cdot $ | $14.1604555 \cdot 162561 \cdot 6151508 \cdot 9870431 \cdot 46 \cdot 35 \cdot 1664819 \cdot 168838 \cdot 5922832 \cdot 9860445 \cdot 2555 \cdot 1722156 \cdot 174827 \cdot 719917 \cdot 9850593 \cdot 9870837 \cdot 718917 \cdot$ | $5 \cdot 1607426 \cdot 162860 \cdot 6 \cdot 140230 \cdot 9869964 \cdot 45 \cdot 36 \cdot 1667687 \cdot 169137 \cdot 5 \cdot 9859960 \cdot 2456 \cdot 1725022 \cdot 175127 \cdot 5 \cdot 710125 \cdot 9850091 \cdot 1250767 \cdot 125076$ | $16.1610297 \cdot 163159 \cdot 6128992 \cdot 9869496 \cdot 44 \cdot 37 \cdot 1670556 \cdot 169436 \cdot 5901913 \cdot 9859475 \cdot 2357 \cdot 1727887 \cdot 175127 \cdot 5 \cdot 700366 \cdot 9849589$ | $7 \cdot 1613167 \cdot 163457 \cdot 6 \cdot 117794 \cdot 9869027 \cdot 4338 \cdot 1673423 \cdot 169735 \cdot 5891508 \cdot 985898 \cdot 2258 \cdot 1730752 \cdot 175727 \cdot 569639 \cdot 9849086 \cdot 175727 \cdot 169738 \cdot $ | $8 \cdot 1616038 \cdot 163756 \cdot 6 \cdot 106636 \cdot 9868557 \cdot 42 \cdot 39 \cdot 1676291 \cdot 170035 \cdot 5 \cdot 881138 \cdot 985851 \cdot 12159 \cdot 1733617 \cdot 176027 \cdot 5 \cdot 680944 \cdot 9848582 \cdot 167628 $ | 1679159 170334 5.870804 9858313 2060 1736482 176327 5.671281 9848078 | | Tang. |
| l'ang. | 170633 | 170933 | 171232 | 171532 | 171831 | 172130 | 172430 | 172730 | 173029 | 173329 | 173628 | 173928 | 174228 | 174527 | 174827 | 175127 | 175127 | 175727 | 176027 | 176327 | | Cotan. |
| Sine. | 1682026 | 1684894 | 1687761 | 1690628 | 1693495 | 1696362 | 1699228 | 1702095 | 1704961 | 1707828 | 1710694 | 1713560 | 1716425 | 1719291 | 1722158 | 1725022 | 1727887 | 1730752 | 1733617 | 1736482 | | Cosine. Cotan. |
| - | 41 | 42 | 43 | 14 | . 91 | 16 | 17 | 18 | 19 | - 09 | -119 | 52 | 53 | 54 | 55 | . 99 | 57 | - 89 | - 69 | . 09 | | - |
| - | 3 39 | 38 | 8 37 | 2 36 | 5 35 | 0 34 | 3 33 | 5 32 | 5 31 | 5 30 | 5 29 | 1 28 | 2 27 | 9 26 | 5 25 | 0,24 | 5 23 | 8 22 | 121 | 3 20 | | - |
| Cosine. | 986714 | 986667 | 9866196 | 9865725 | 986524 | 986477 | 9864293 | 986381 | 9863336 | 9862856 | 986237 | 9861894 | 9861415 | 986092 | 986014 | 982996 | 985947 | 9858988 | .985850 | :108286- | | Sine. |
| Cotang. | 6-073397 | 8-062396 | 6-051434 | 6-040510 | 6.029624 | 6-018777 | 296200-9 | 5-997195 | 5-986461 | 5-975764 | 5-965104 | 5-954481 | 5-943895 | 5-933345 | 5.922832 | 5-912355 | 5-901913 | 5.891508 | 5.881138 | 5-870804 | | Tang. |
| Tang. | 164652 | 164951 | 165250 | 165548 | 165847 | 166146 | 166445 | 166744 | 167043 | 167342 | 167641 | 167940 | 168239 | 168239 | 168838 | 169137 | 169436 | 169735 | 170035 | 170334 | | Cotan. |
| Sine. | 1624650 | 1627520 | 1630390 | 1633260 | 1636129 | 1638999 | 164186S | 1644738 | 1647607 | 1650476 | 1653345 | 1656214 | 1659082 | 1661991 | 1664819 | 1667687 | 1670556 | 1673423 | 1676291 | 1679159 | | Cosine. |
| - | 21 | 22 | 23 | 24 | 25 | 26 | 37 | 281 | 58 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 01 | | - |
| - | 09 | 59 | 58 | 57 | 56 | 55 | 54 | 53 | 52 | 51 | 50 | 49 | 48 | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 40 | - |
| Cosine. | 9876883 | -9876428 | 9875972 | 9875514 | 9875057 | 9874598 | 9874138 | 9873678 | .9873216 | 9872754 | 9872291 | 9871827 | 9871363 | -9870897 | 9870431 | -9869964 | 9869496 | 1206986 | 9868557 | 9868087 | 9867615 | Sine. |
| Cotang. | 8-313751 | 6-301886 | 8-290065 | 6.278286 | 6-266551 | 8-254858 | 8-243208 | 8-231600 | 5-220034 | 8-208510 | 8-197027 | 8-185586 | 8-174186 | 8-162827 | 8-151508 | 8-140230 | 8-128992 | 8-117794 | 8-106636 | 19 1618939 164055 6-095517 9868087 41 40 | 20 -1621779 -164353 6-084438 -9867615 40 | Tang. |
| Tang. | 158384 | 158682 | 158980 | 159279 | 159577 | 159875 | 160174 | 160472 | 160770 | 690191 | 161367 | 161666 | 161964 | 162263 | 162561 | 162860 | 163159 | 163457 | 163756 | 164055 | 164353 | Cotan. |
| Sine. | 1561345 | 1567218 | 1570091 | 1572963 | 1575836 | 1578708 | 1581581 | 1584453 | 1587325 | 1590197 | 1593069 | 1595940 | 1598812 | 1601683 | 1604555 | 1607426 | 1610297 | 1613167 | 1616038 | 6068191 | 1621779 | Cosine. |
| - | 0 | - | -2 | 00 | + | 5 | 9 | 7 | 00 | 6 | 0 | = | 63 | 3 | - | 10 | 9 | 1 | 00 | 6 | 0 | |

NATURAL SINES AND TANGENTS TO A RADIUS 1.

| 34 | | 1 | Al | BLE | 3 (| F | SI | NE | s, | Т | A | NG | E | NI | S, | E | TC | | | |
|--------------|-----------------|--|--|--|---|---|---|--|--|--|--|--|--|--|--|--|---|--|---|-----------------|
| | E | 16 | 81 | 119 | 15 | 14 | 5 6 | | 10 | 6 | 00 | 1 | 9 | 0 | 40 | 20 | 2 - | 10 | | 1- |
| | Cosine. | -9826668 | 9826128 | 9825587 | 9824504 | 19823961 | -9823417 | 9822327 | -9821781 | 9821234 | 9820686 | -9820137 | -9819587 | -9819037 | -9818485 | 0007100 | 9669180 | 9816272 | | Sine. |
| | Cotang. | 5-300801 | 5-292350 | 5.275525 | 5-267151 | 5-258803 | 5-242183 | 5-233911 | 5-225664 | 5-217442 | 5-209245 | 1888098 -192268 5-201073 -9820137 | 5-192926 | 5-184803 | 5-176705 | 5.160561 | 5.159555 | 5-144554 | | Tang. |
| | Tang. | 188650 | 188952 | 189253 | 189855 | 190157 | 190458 | 190161 | 191363 | 191664 | 191966 | .192268 | 192569 | 192871 | 193173 | 1102776 | 1.104078 | 194380 | | Cotang. |
| 10 Deg. | Sine. | 1853808 | 1856666 | 1862382 | 1865240 | 1868098 | 1873813 | 1876670 | 1879528 | 1882385 | 1885241 | 1888098 | 1890954 | 18893811 | 1896667 | 0288601 | 1905924 | 1908090 | | Cosine, Cotang. |
| 10 | 1 | 3941 | 38 42 | 36 44 | 35 45 | 34 46 | 32.48 | 31 49 | 30 50 | 29.51 | 28 22 | 27 53 | 26 54 | 25 55 | 24 56 | 20 00 | 2159 | 09 02 | | 11 |
| Deg. 10 Deg. | Cosine. | 9837286 | 9836763 | 9835715 | 9835189 | 9834663 | 9833608 | 9833079 | 9832549 | 9832019 | 9831487 | 9830955 | 9830422 | 8886386 | 0100000 | 9898989 | 9827744 | 10 1850949 188349 5-309279 9827206 20(60 1908090 194380 5-144554 9816272 | | Sine. |
| | Tang. Cotang. | 5-475478 | 5.466481 | 5-448571 | 5-439659 | 5-430775 | 5-413090 | 5-404290 | 5-395517 | 5-386771 | 5-378053 | 5-369363 | 5-360699 | 5.352062 | 5-334869 | 5-326313 | 5-317783 | 5-309279 | 100000000000000000000000000000000000000 | Tang. |
| | Tang. | 182632 | 182933 | 183534 | 183835 | 184135 | 184737 | 185038 | 185339 | 185639 | 185940 | 186241 | 186542 | 186843 | 187448 | 187747 | 188048 | 188349 | | Cotang. |
| 10 Deg. | Sine. | 1796607 | 1799469 | 1805191 | 1808052 | 1810913 | 1816635 | 1819495 | 1822355 | 1825215 | 1828075 | 1830935 | 1833795 | 100001 | 1849373 | 1845232 | 1848091 | 1850949 | | Cosine. Cotang. |
| 10 | - | 21 | 250 | 2 4 | 325 | 926 | 328 | 538 | 30 | 31 | 35 | 33 | 34 | 200 | 37 | 38 | 39 | | | - |
| | Cosine. | 0671281 9848078 60/21 1796607 182632 5-475478 9837286 39/41 1853808 188650 5-300801 9826668 19 | 1739346 176626 1-661650 -9847572 5922 1799469 182933 5-466481 -9836763 3842 1856666 188952 5-292350 -9826128 | 3-1745075-177226 5-642483 9846558 5724 1805191-183534 5-48571 9835715 3644 1862382 189554 5-275525 9825041 | 1747939 177527 5-632947 9846050 5625 1808052 183835 5-439659 9835189 3545 1865240 189855 5-267151 6824504 155 | 0.1759803 177827 5 623442 9845542 5526 1810913 184135 5 430775 9834663 3446 1868098 190157 5 258803 9823961 1 | -1756531 178427 5-604524 9844521 5328 1816635 184737 5-413090 9833608 3248-1873813-190468 5-249183-68998-33 | $8.1759395 \cdot 178727 \cdot 5\cdot595112 \cdot 9844010 \cdot 52 \cdot 29 \cdot 1819495 \cdot 185038 \cdot 5\cdot404290 \cdot 9833079 \cdot 3149 \cdot 1876670 \cdot 191061 \cdot 5\cdot233911 \cdot 9822327 \cdot 187670 \cdot 191061 | $9 \cdot 762258 \cdot 179027 \cdot 5 \cdot 585730 \cdot 9843498 \cdot 51 \cdot 30 \cdot 1822355 \cdot 185339 \cdot 5 \cdot 395517 \cdot 9832549 \cdot 30 \cdot 50 \cdot 1879528 \cdot 191363 \cdot 5 \cdot 225664 \cdot 9821781 \cdot 9832549 \cdot 30 \cdot 50 \cdot 1879528 \cdot 191363 \cdot 5 \cdot 225664 \cdot 9821781 \cdot 9832549 \cdot 30 \cdot 50 \cdot 1879528 \cdot 191363 \cdot 5 \cdot 225664 \cdot 9821781 \cdot 9832649 \cdot 30 \cdot 50 \cdot 1879528 \cdot 191363 \cdot 5 \cdot 225664 \cdot 9821781 \cdot 9832649 \cdot 30 \cdot 50 \cdot 1879528 \cdot 191363 \cdot 5 \cdot 225664 \cdot 30 \cdot 5 \cdot 1879528 \cdot 191363 \cdot 19$ | $0.1765121 \cdot 1793275 \cdot 5.576378 \cdot 9842985 \cdot 50 \cdot 311 \cdot 1825215 \cdot 185639 \cdot 5 \cdot 386771 \cdot 9832019 \cdot 2951 \cdot 1882385 \cdot 191664 \cdot 5 \cdot 217442 \cdot 9821234 \cdot 1865121 \cdot$ | $1.1767984 \cdot 179628 \cdot 5567057 \cdot 9442471 \cdot 49132 \cdot 185940 \cdot 578053 \cdot 9831487 \cdot 285241 \cdot 191966 \cdot 5.209245 \cdot 9820686 \cdot 385241 \cdot 191966 \cdot 191966 \cdot 191968 \cdot 19$ | 2.17708471179928 5.557766 9841956 48 33.1830935 186241 5.369363 9830955 2753.1 | 1777 17 17 17 18 18 18 18 18 18 18 18 18 18 18 18 18 | 11 (100.10) | 6.7782258. I 129 5:520900. 4339889 44 (7) - 1442373 - 187448 f. 234866 f. 187448 f. 23486 f. 2350 f. 2 | 7.1785160-181430 5-511757 9839370 43 8-1845-232 1877415 526 313 48982829 5958 109320 139320 13051295 | 8-1788022-18173015-502644-9838850142-39-18480911-188048-5-317783-982774-4-159-19079-5-15-6-5-5-6-6-6-6-6-6-6-6-6-6-6-6-6-6- | 19-1790884 -182031 5-493560 -9838330 11 | 20 1793746 182331 5.484505 9837808 40 | Sine. / |
| | Tang. Cotang. | 1821194 | 5.661650 | 5-642483 | 5-632947 | 5.613968 | 5-604524 | 5-595112 | 5.585730 | 5-576378 | 5.567057 | 5-557766 | 5.596500 | 5.590079 | 5-520900 | 5-511757 | 5-502644 | 5-493560 | 5-484505 | Tang. |
| | Tang. | 176327 | 176626 | -177226 | 177527 | 1781971 | 178427 | 178727 | 179027 | 179327 | 179628 | 179928 | 100500 | 180890 | 181129 | 181430 | 181730 | -182031 | 182331 | Cotang. |
| 10 Deg. | Sme. | 1736482 176327 | 1739346 | -1745075 | 1747939 | 1753667 | -1756531 | 1759395 | 1762258 | 1216971 | 1767984 | 1770817 | 1776670 | 1779435 | 1782298 | 1785160 | ·1788022 | 1790884 | 1793746 | Cosine. Cotang. |
| 2 1 | - | 0 | - 64 | 00 | 4 | 9 | 7 | 00 | 6 | 10 | 11 | 3 0 | 5. | 1 15 | 16 | 17 | 118 | 19 | 20 | 3 |

Pag. 70.

Deg. 79.

Deg. 79.

| | 61 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | | 01 | 6 | 00 | 7 | 9 | 5 | 4 | 3 | 25 | - | 9 | 1 | - | 04 |
|-----------------|---|--|--|---|--|--|---|--|---|--|--|--|--|---------------|---|--|--|--|---|---|---------------------------------------|-------------------|--------|
| Cosine. | 91 9804433 39 11 -2025024 -206786 4-835901 -9792818 19804433 39 11 -2025024 -206786 4-835901 -9792818 | $\frac{910945}{94682} \cdot \frac{94682}{5} \cdot \frac{36576}{3} \cdot \frac{9815716}{5} \cdot \frac{5922}{3} \cdot \frac{1970870}{5} \cdot \frac{201030}{3} \cdot \frac{4.974381}{9483} \cdot \frac{9803860}{948381} \cdot \frac{3842}{94882} \cdot \frac{2027873}{94682} \cdot \frac{2027877}{94682} \cdot \frac{2027877}{94682} \cdot \frac{2027877}{94682} \cdot \frac{202787}{94682} \cdot \frac{202787}{94682} \cdot \frac$ | $\frac{913801}{913801} \cdot \frac{94984}{5} \cdot \frac{5}{128622} \cdot \frac{9815}{9815} \cdot \frac{90328}{6} \cdot \frac{973722}{5} \cdot \frac{201332}{5} \cdot \frac{4}{1286903} \cdot \frac{96903286}{913801} \cdot \frac{3743}{5} \cdot \frac{2030721}{913801} \cdot \frac{207393}{5} \cdot \frac{1921753}{913801} \cdot \frac{973722}{913801} \cdot \frac{9815}{913801} \cdot \frac{9815}$ | $916656 \cdot 95286 \cdot 5 \cdot 120692 \cdot 9814603 \cdot 5724 \cdot 1976573 \cdot 201635 \cdot 4 \cdot 959447 \cdot 9802712 \cdot 36 \cdot 44 \cdot 2033569 \cdot 207696 \cdot 4 \cdot 814709 \cdot 9791047 \cdot 16 \cdot 1$ | $919510 \cdot 195588 \ 5 \cdot 112785 \cdot 9814045 \ 5 6 25 \cdot 1979425 \cdot 201938 \ 4 \cdot 952012 \cdot 9802136 \ 3545 \cdot 2036418 \cdot 208000 \ 4 \cdot 807685 \cdot 9790455 \ 15 \cdot $ | $92236 \cdot 195890 \cdot 5 \cdot 104902 \cdot 98 \cdot 13486 \cdot 5526 \cdot 1982276 \cdot 202240 \cdot 4 \cdot 944599 \cdot 9801560 \cdot 34 \cdot 46 \cdot 2039265 \cdot 208303 \cdot 4 \cdot 800680 \cdot 9789862 \cdot 186 \cdot 198868 \cdot 1988$ | $925220 \cdot 96192 \cdot 5 \cdot 097042 \cdot 9812927 \cdot 5127 \cdot 1985127 \cdot 202548 \cdot 14 \cdot 937206 \cdot 9800985 \cdot 3347 \cdot 2042113 \cdot 208607 \cdot 4 \cdot 793695 \cdot 9789268 \cdot 13 \cdot 208008 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10$ | 928074.196494.5.089206.9812366.5328.1987978.2028464.929835.9800405.3248.2044961.208910.4786730.9788674 | 9788079 | 9787483 | 9889846 | 9786288 | 9785689 | 9785090 | 9784490 | 9783889 | 9783287 | 9782684 | 9782080 | 9781476 | 1 | Sine. | Dog 78 |
| Tang. Cotang. | 4-835901 | 4.828817 | 1.821753 | 4.814709 | 4-807685 | 4-800680 | 4-793695 | 4-786730 | 2047808 209214 4-779783 9788079 | $0.1933789. \cdot 97098. \cdot 6.073602. \cdot 9811243. \cdot 5130. \cdot 1993679. \cdot 203452. \cdot 4.915157. \cdot 9799247. \cdot 30. \cdot 50.50655. \cdot 209518. \cdot 4.772856. \cdot 9787483. \cdot 97098. \cdot 5.073602. \cdot 9811243. \cdot 5130. \cdot 1993679. \cdot 203452. \cdot 4.915157. \cdot 9799247. \cdot 30. \cdot 50. \cdot $ | $\begin{array}{c} \cdot | $\begin{array}{c} + 939490 \\ -939490 \\ -9703 \\ \hline \end{array} \begin{array}{c} -966349 \\ -2056349 \\ -201025 \\ \hline \end{array} \begin{array}{c} -978086 \\ -978086 \\ -978086 \\ \hline \end{array} \begin{array}{c} -978086 \\ -9$ | 980055 - 980055 - 9603569 - 980955249 - 33 - 2002230 - 204361 + 893295 - 9797504 - 2753 - 2059195 - 210429 + 752190 - 9785689 - 1042344 - 108005 - 200420 - 1042344 - 108005 - 200420 - 104204 - 108005 - 200420 - 104234 - 108005 - 200420 - 104234 - 108005 - 200420 - 104234 - 108005 - 200420 - 104234 - 108005 - 200420 - 104234 - 108005 - 104234 - 108005 - 104234 - 108005 - 104234 - 108005 - 104234 - 108005 - 104234 - 108005 - 104234 - 108005 - 104234 - 108005 - 104234 - 108005 - 104234 - 108005 - 104234 - 108005 - 104234 - 108005 - 104234 - 108005 - 104234 - 108005 - 104234 - 108005 - 104234 - 108005 | $\frac{1}{2}$ | $\frac{4.87824}{1.148050 \cdot 198610} \cdot \frac{9861}{1.048050} \cdot 1000000000000000000000000000000000000$ | $\frac{1.950903}{1.98912} \cdot \frac{98912}{1.98912} \cdot \frac{1.98912}{1.98912} \cdot \frac{9.90783}{1.98912} \cdot \frac{9.90783}{1.99912} \cdot \frac{9.90783}{1.99912} \cdot$ | $0.953756 \cdot 99214 \cdot 5 \cdot 19707 \cdot 9807285 \cdot 4437 \cdot 2013629 \cdot 205573 \cdot 4 \cdot 864435 \cdot 9795167 \cdot 2357 \cdot 2070580 \cdot 211644 \cdot 4 \cdot 724901 \cdot 9783287 \cdot 2070580 \cdot 211644 \cdot 724901 \cdot 9783287 \cdot 2070580 \cdot 2070500 \cdot 2070500 \cdot 207050 \cdot 2070500 \cdot 2070500 \cdot 2070500 \cdot 2070500 $ | . 956609 . 99517 5-012098 . 986716 4338 . 2016478 . 205876 4.857271 . 9794581 2258 . 2073426 . 211948 4.718125 . 9782684 | 8.1659461.998195.004511.98061474239:2019327:2061804.850128.97939942159:2076272:2122524.711368.9782080 | 9-1962314-200122 4-996945-9805576 4140-2022176-206483 4-843004-9793406 2060-2079117-212556 4-704630-9781476 | | Tang. | |
| Tang. | 206786 | 207090 | -207393 | -207696 | 000802- | -208303 | -208607 | .208910 | -209214 | 819602 | 209821 | 210125 | -210429 | -210733, | -211036 | -211340 | -211644 | -211948 | -212252 | -212556 | V | Cotang. | |
| Sine. | 2025024 | 2027873 | 2030721 | 2033569 | 2036418 | 2039265 | 2042113 | 2044961 | 2047808 | 2050655 | 2053502 | 2056349 | 2059195 | 2062042 | 2064888 | 2067734 | 2070580 | 2073426 | 2076272 | 2079117 | | Cosine. Cotang. | |
| | 3 11 | 8 42 | 743 | 544 | 545 | 9 1 | 347 | 248 | 67 | 090 | 951 | 8 52 | 753 | 854 | 555 | 1 56 | 357 | 892 | 1 59 | . 09(| | 11 | 1 |
| , | 3 | 0 38 | 6 3 | 2 30 | 6 3 | 0 34 | \$ 3 | 5 3 | 73 | 7 3 | 7 2 | 6 2 | 1 2 | 1.2 | 7 2 | 2 2 | 7 2 | 1 2 | 4 2 | 6 20 | | | NO. |
| Cosine. | 980443 | 980386 | 980328 | -980271 | .980213 | 980156 | 860086 | .980040 | -979982 | 979924 | 998626 | 979808 | 979750 | -979692 | 979633 | 979575 | 979516 | 979458 | 979399 | 979340 | | Sine. | - |
| Tang. Cotang. | 4.981881 | 4.974381 | 4.966903 | 4-959447 | 4.952012 | 4-944599 | 4.937206 | 4.929835 | 930928 .196796 5.081392 .9811805 5229 .1990829 .203149 4-922485 .9799827 3149 | 4-915157 | 4.907849 | 4-900562 | 4.893295 | 4.886049 | 4.878824 | 4-871620 | 4.864435 | 4-857271 | 4.850128 | 4.843004 | | Tang. | |
| Tang. | 200727 | 201030 | 201332 | 201635 | -201938 | 202240 | 202543 | 202846 | 203149 | 203452 | 203755 | 204058 | 204361 | 204664 | 204967 | 205270 | 205573 | 205876 | 206180 | 206483 | | Cotang. | |
| Sine. | 1968018 | 0280791 | 1973722 | 1976573 | 1979425 | 1982276 | 1985127 | 1987978 | 1990829 | 1993679 | 1996530 | 1999380 | 2002230 | 2005080 | 2007930 | 2010779 | 2013629 | 2016478 | 2019327 | 2022176 | | / Cosine. Cotang. | |
| , | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 88 | 29 | 30 | 31. | 35 | 331 | 34 | 35 | 36 | 37 | 38 | 391 | 40 | 7 (| - | - |
| - | 09 | 59 | 58 | 57 | 56 | 55 | 51 | 53 | 52 | 51 | 50 | 49 | 48 | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 40 | - | 1 |
| Cosine. | -9816272 | 9815716 | 9815160 | -9814603 | 9814045 | -9813486 | -9812927 | -981236€ | -9811805 | .9811243 | 9810680 | 9810116 | 9809552 | 9808986 | 9808420 | 9807853 | 9807285 | 9806716 | 9806147 | 9805576 | -9805005 | Sine. | |
| Cotang. | 5-144554 | 5-136576 | 5-128622 | 5-120692 | 5-112785 | 5.104902 | 5.097042 | 5-089206 | 5.081392 | 5-073602 | 5.065835 | 5-058090 | 5-050389 | 5.042670 | 5-034993 | 5-027339 | 5-019707 | 5-012098 | 5.004511 | 1-996945 | 1.989402 | Tang. | |
| Tang. | 194380 | 194682 | 194984 | 195286 | 195588 | 195890 | 196192 | 196494 | 1967961 | 860261 | 197400 | 197703 | 198005 | 198307 | 019861 | 198912 | 199914 | 719961 | 199819 | 200122 | 200424 | Cotang. | |
| Sine. | 000000 | 910945 | 913801 | 916656 | 1919510 | 1922365 | 1925220 | 1928074 | 1930928 | 1933789 | 1986886 | 1939490 | 1942344 | 1945197 | 1948050 | 1950903 | 1953756 | 1956609 | 1959461 | 1962314 | 90 1965166 200424 4.989402 9805005 40 | Cosine. | |
| | 1 . | - | . 6 | 000 | 4 | 1 10 | 9 | 1 | · CZ | 0 | 00 | - | - 6 | 2 00 | 7 | 1 10 | 0 00 | 1 | - 0 | 0 | 0 | 1- | 1 |

NATURAL SINES AND TANGENTS TO A RADIUS 1.

| | | ** | TDI | 11. | C/ | | 244 | 133 | , | * | - | | - | | 100 | No. | - | | | | | |
|---------|---------------|---|---|--|--|--|---|--|---|--|--|--|--|--|--|--|--|--|--|--|------------------------------|----------|
| 1 | - 1 | 61 | 17 | 16 | 15 | 13 | - | 11 | 10 | 6 | 00 | 7 | 9 | 2 | 4 | 33 | C.S. | 1 | 0 | T | | 77. |
| | Cosine. | -2079117 -212556 4-704630 -9781476 6021 -2138829 -218949 4-567261 -9768593 3941 -2195624 -225054 4-443376 -9755985 19 | $\begin{array}{c} -2081962 \cdot 212860 \ 4 \cdot 697910 \cdot 9780871 \ 59722 \cdot 2141671 \cdot 219254 \ 4 \cdot 560911 \cdot 3767970 \ 38142 \cdot 2139462 \cdot 225565 \ 4 \cdot 431339 \cdot 9754706 \end{array}$ | 2087652.2134894.684524.977965815724.2147353.2198844.548260.97667233644.2204137.2259714425343.9754065816782371676723367167672371676723716767237167672371676723716767237167672371676723716767237167672371676723716767237167677237167727167727167727167727167727167727167727167727167727167727167727167727167727171677271677271716772717167727171677271716772717167727171677271716772717167727171677271716772717167727171716771717171 | 2090497 213773 4.677859 9779050 5625 2150194 220169 4.541960 9766098 3545 2206974 226276 4.419364 9753423 15 | $2093341 \cdot 2140774 \cdot 4 \cdot 671212 \cdot 9778441 \cdot 5526 \cdot 2153035 \cdot 220474 \cdot 4 \cdot 535677 \cdot 9765472 \cdot 3446 \cdot 2209811 \cdot 226582 \cdot 4 \cdot 13339 \cdot 3752138 \cdot 906816 \cdot 226888 \cdot 4 \cdot 407450 \cdot 9752138$ | 2090030 214659 4 657972 9777222 5328, 2158716 -22186 9764217 3248 -2215485 -227194 4-401516 9751494 | $-310 1874 \cdot 214990 + 651378 \cdot 9776611 \mid 52 \mid 29 \mid -2161556 \cdot 291389 \mid 4 \cdot 516926 \cdot 9763589 \mid 3149 \mid -2218321 \mid -227500 \mid 4 \cdot 395597 \mid -9750849 \mid -2218321 \mid -227500 \mid 4 \cdot 395597 \mid -9750849 \mid -2218321 \mid -227500 \mid -2218321 \mid -227500 \mid -2218321 | $-2104718 \cdot 215294 \cdot 644803 \cdot 9775999 \cdot 5180 \cdot 2164396 \cdot 221694 \cdot 4 \cdot 510708 \cdot 9762960 \cdot 3050 \cdot 2221158 \cdot 227806 \cdot 4 \cdot 389694 \cdot 9750203 \cdot 3221158 \cdot 227806 \cdot 4 \cdot 389694 \cdot 9750203 \cdot 9750203 \cdot 9750203 \cdot 9750200 \cdot 97502000 0000000000000000000000000000000$ | $\cdot 2107561 \cdot 215598 \cdot 1 \cdot 638245 \cdot 9775386 \cdot 5031 \cdot 2167236 \cdot 221999 \cdot 4 \cdot 504507 \cdot 9762330 \cdot 2911 \cdot 2223994 \cdot 228112 \cdot 4 \cdot 383805 \cdot 9749556 \cdot 210761 \cdot 210$ | $-2110405 \cdot 215903 \cdot 4 \cdot 631705 \cdot 9774773 \cdot 49^{\circ}32 \cdot 2170076 \cdot 222305 \cdot 4 \cdot 498321 \cdot 9761699 \cdot 28^{\circ}52 \cdot 2226830 \cdot 228418 \cdot 4 \cdot 377931 \cdot 9748909 \cdot 28870 \cdot 2226830 \cdot 228418 \cdot 4 \cdot 377931 \cdot 9748909 \cdot 28870 | 9748261 | $ \cdot 2116191 \cdot 216512 \cdot 4 \cdot 618678 \cdot 9773544 \cdot 4734 \cdot 2175754 \cdot 222915 \cdot 4 \cdot 486000 \cdot 9760435 \cdot 2654 \cdot 2232501 \cdot 229030 \cdot 4 \cdot 366229 \cdot 9747612 \cdot 216076 \cdot 21$ | $2118934 \cdot 216816 \cdot 4 \cdot 612190 \cdot 9772928 \cdot 4635 \cdot 2178593 \cdot 223221 \cdot 4 \cdot 479863 \cdot 9759802 \cdot 25155 \cdot 2235337 \cdot 229336 \cdot 4 \cdot 360400 \cdot 9746962 \cdot 26189 \cdot$ | -9746311 | $\cdot 2124619 \cdot 217425 \cdot 4 \cdot 599268 \cdot 9771693 \cdot 4437 \cdot 2184271 \cdot 223831 \cdot 4 \cdot 467637 \cdot 9758533 \cdot 2357 \cdot 2241007 \cdot 229949 \cdot 4 \cdot 345786 \cdot 9745660 \cdot 229449 \cdot 4 \cdot 345786 \cdot 9745660 \cdot 3745660 \cdot 3746600 \cdot 3745660 \cdot 3745600 \cdot $ | 22462 217730 4592832 9771075 438 2187110 221137 4461548 9757897 2258 2243842 230255 454300 9745008 | $2130334 \cdot 2180354 \cdot 586414 \cdot 9770456 \cdot 42391 \cdot 21899481 \cdot 22444214 \cdot 4554751 \cdot 9757260 \cdot 21591 \cdot 22466761 \cdot 23056114 \cdot 3372311 \cdot 97443551 \cdot 9744351 \cdot 974541 \cdot $ | 9743701 | | Sine. | Deg |
| | Cotang. | 4-443376 | 4-43/339 | 4 425343 | 4-419364 | 4-413399 | 4-401516 | 4.395597 | 4.389694 | 4.383805 | 4.377931 | $2113248 \cdot 216207 + 625183 \cdot 9774159 \cdot 48 \cdot 33 \cdot 2172915 \cdot 222610 + 492153 \cdot 9761067 \cdot 2753 \cdot 2229666 \cdot 228724 + 372073 \cdot 9748261$ | 4.366229 | 4.360400 | $\cdot 2121777 \cdot 217121 \cdot 4605720 \cdot 9772311 \cdot 45 \cdot 36 \cdot 2181432 \cdot 223526 \cdot 4473742 \cdot 9759168 \cdot 2456 \cdot 2238172 \cdot 229642 \cdot 451586 \cdot 9746311 \cdot 9759168 \cdot 475747 \cdot 9759168 \cdot 475747 \cdot 9759168 \cdot 475747 $ | 4.348786 | 4.343001 | 4-337231 | $9 \cdot 2133146 \cdot 218340 \cdot 4 \cdot 580012 \cdot 9769836 \cdot 4140 \cdot 2192786 \cdot 221748 \cdot 449418 \cdot 9756623 \cdot 2060 \cdot 2249511 \cdot 230868 \cdot 331475 \cdot 9743701 \cdot 230868 \cdot 218340 \cdot $ | | Tang. | |
| | Tang. | -225054 | -225665 | .225971 | -226276 | 226582 | -227194 | -227500 | -227806 | .228112 | .228418 | -228724 | -229030 | -229336 | -229642 | 229949 | -230255 | -230561 | -230868 | 1 | Cotang. | |
| 12 Deg. | Sine. | 2195624 | 2201300 | 2204137 | 2206974 | 2209811 | 2215485 | 2218321 | 2221158 | 2223994 | -2226830 | .2229666 | 2232501 | -2235337 | -2238172 | -2241007 | -2243842 | -2246676 | .2249511 | | / / Cosine. Cotang. Tang. | 1 |
| 12 | - | 17 | 2 5 | 4 | 45 | 46 | 48 | 49 | 20 | 21 | 52 | 53 | 54 | 55 | 99 | 24 | 28 | 59 | 09 | | | Į, |
| | - | 3 39 | 37 37 | 3 36 | 3 35 | 233 | 7 32 | 331 | 30 | 29 | 388 | 127 | 5 26 | 2 25 | 3 24 | 3 23 | 7 22 | 0 21 | 205 | | - | 77. |
| | Cosine. | 976859 | 976797 | 976672 | 609946 | 9765473 | 9764217 | 9763589 | 976296 | -976233(| 9761698 | -9761067 | -9760438 | 9759805 | -9759168 | 975853 | 975789 | 975726 | -975662 | | Sine. | Deg. 77. |
| | Tang. Cotang. | 4-567261 | 4-560911 | 4.548260 | 4.541960 | 4-535677 | 4-523160 | 4.516926 | 4.510708 | 4.504507 | 4.498322 | 4.492153 | 4.486000 | 4.479863 | 4-473742 | 4-467637 | 4.461548 | 4.455475 | 4-449418 | | Tang. | |
| | Tang. | -218949 | -219254 | -219864 | -220169 | -220474 | -221084 | .221389 | -221694 | 666122 | -222305 | -222610 | 222915 | -223221 | -223526 | -223831 | -221137 | -224442 | -221748 | | Cotang. | |
| 12 Deg. | Sine. | 2138829 | 2141671 | 2147353 | 2150194 | 2153035 | 2158716 | 2161556 | 2164396 | 2167236 | 2170076 | 2172915 | 2175754 | 2178593 | 2181432 | 2184271 | 2187110 | 2189948 | 2192786 | | ' Cosine. Cotang. | |
| 123 | | 21 | 22 22 | 24 | 25 | 26 | 28 | 50 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 391 | 40 | | - | |
| | , | 60 | 58 | 57 | 96 | 54 | 53 | 52 | 51 | 50 | 49 | 48 | 47 | 46 | 45 | 44 | 43 | 142 | 41 | 40 | 1 | 77. |
| 1 | Cosina, | 9781476 | ·9780265 | 9779658 | -9779050 | 9778441 | 9777222 | 1199776 | 9775999 | 9775386 | 9774778 | 9774159 | -9773544 | -9772928 | 9772311 | -9771693 | 9771075 | -9770456 | 926926 | -9769215 | Sine. | Deg. 77. |
| | Cotang. | 4-704630 | 4.697910 | 4.684524 | 4-677859 | 4.671212 | 4.657972 | 4.651378 | 4.644803 | 1.638245 | 4-631705 | 4-625183 | 4.618678 | 4-612190 | 4.605720 | 4.599268 | 4.592832 | 4.586414 | 4-580012 | 4.573628 | Tang. | |
| | Tang. | -212556 | 212860 | -213468 | -213773 | 214077 | 214685 | -214990 | -215294 | -215598 | -215903 | -216207 | 216512 | 216816 | -217121 | -217425 | -217730 | -218035 | -218340 | 218641 | Cotang. | |
| 12 Deg. | sine. | 2079117 | 2081962 | 2087652 | 2090497 | 2093341 | 2099030 | 2101874 | 2104718 | 2107561 | 2110405 | 2113248 | 1609112 | 2118934 | 2121777 | 2124619 | -2127462 | 2130334 | 2133146 | 20 -2135988 -218644 4-573628 -9769215 40 | Cosine. Cotang. | - |
| 2 | - | 10 | - 0 | 33 | 4 | KO (4 | 10 | 20 | 0 | 16 | 7 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 61 | 20 | 4 | |
| - | | | | | | | | | | | | | | | | | | | | | | |

NATURAL SINES AND TANGENTS TO A RADIUS 1.

| 9 237311 4-213869 -9729777 3941 -2365555 9 237618 4-209819 -9729777 3941 -2365555 9 237926 4-209839 -9728132 3713 -2371207 9 237926 4-209839 -9728132 3713 -2376839 123834 4-197560 -9727784 35 45 -2376839 17 239156 4-181371 -9725783 3347 -2382510 16 239463 4-176001 -9725056 32 18 -2385355 15 239463 4-176001 -9725059 3050 -2399094 12 240078 4-154550 -972539 28 52 -2396633 18 241001 4-14934 -972158 2753-239964 10 240694 4-15450 -972239 28 52 -2396633 18 241001 4-138771 -972034 25 55 -2405104 14 211617 4-138771 -972034 25 55 -2410751 15 242531 4-123007 -9718440 22 58 -2416390 12 24241 4-123007 -971840 22 58 -2416390 12 242849 -9718567 20 60 -2419219 | Cotone Cosine 1 | Cotone Cosine 1 | Cotone Cosine 1 | 101 | Barrell Sir | Sar of | S S | - | | | Coming | - | 13 Deg. | in or | Pare | Cotono | Coeina | - |
|--|---|---|---|--------------------|-------------|----------|------|---------|---------|----------|----------|-----|---------|--------|---------|----------|----------|-----|
| | ome. | Cotaing, Cosme, | Cotaing, Cosme, | 1 | Ome | Ome | Sine | 1 | rang. | Cotang. | Cosme | | - | onne. | Lang. | Cotang. | COSING. | -1 |
| | 2249511 -230868 4-331475 -9743701 6021 -2308 | ·230868 4·331475 ·9743701 6021 ·2308 | 4.331475 -9743701 60 21 -2308 | 9743701 6021 -2308 | 6021 -2308 | 21 -2308 | 308 | 686 | 237311 | 4-213869 | 9729777 | 394 | 1 .2: | 65555 | 243465 | 4-107356 | .9716180 | 19 |
| | 2252345 -231174 4-325734 -9743046 5922 -231 | -231174 4-325734 -9743046 5922 -231 | 4-325734 -9743046 59 22 -231 | 9743046 5922 -231 | 59 22 -231 | 182 -231 | 31 | 1819 | 237618 | 4.208419 | 9729105 | 384 | 2 .2 | 188381 | -243773 | 4-102164 | .9715491 | 18 |
| 222222 | 2255179 231481 4.320007 9742390 58 23 23 | 231481 4-320007 9742390 58 23 23 | 4-320007 9742390 58 23 23 | 9742390 58 23 -23 | 58 23 -23 | 3 -23 | 9 | 14649 | 237926 | 4.202983 | -9728432 | 371 | 3 .2 | 11207 | 244081 | 4.096985 | .9714802 | 17 |
| 22222 | 2258013 231787 4-314295 9741734 5724 -23 | 231787 4-314295 -9741734 57 24 -23 | 4-314295 -9741734 57 24 -23 | 9741734 57 24 -23 | 57 24 .23 | 14 .28 | 20 | 17479 | 238233 | 4-197560 | 9727759 | 36 | 4.2 | 174033 | .244390 | 4.091817 | .9714112 | 16 |
| 2222 | 2260846 232094 4.308597 9741077 5625 25 | 232094 4.308597 9741077 5625 2: | 4-308597 -9741077 5625 -2: | 9741077 5625 -2: | 56 25 -23 | 25 -2: | 4.0 | 320309 | 238541 | 4-192151 | -9727084 | 354 | 5 -2 | 69894 | 244698 | 4-086662 | 9713421 | 15 |
| 1222 | 2263680 232100 1.302913 9740419 55 26 .2 | -232100 1-302913 -9740419 5526 -2 | 4.302913 9740419 5526 -2 | 9740419 55 26 -2 | 55 26 -2 | 26 -2 | | 323138 | 238848 | 4-186754 | 9726409 | 344 | 6 2 | 179684 | -245006 | 4.081519 | 9712729 | 14 |
| 222 | 2266513 -232707 4-297244 -9739760 5427 -23 | -232707 4-297244 -9739760 5427 -23 | 4-297244 -9739760 5427 -2: | 9739760 54 27 -23 | 54 27 -23 | 2. 12 | 12 | 325967 | 239156 | 4-181371 | 9725733 | 334 | 7 .2: | 882510 | 245315 | 4.076389 | .9712036 | 13 |
| | 2269346, 233014 4.291588, 9739100 5328, 23 | 233014 4-291588 9739100 5328 -23 | 4-291588, 9739100 5328, 23 | 9739100 53 28 -23 | 53 28 -23 | 88 .2 | 200 | 328796 | 239463 | 4.176001 | 9725056 | 321 | 8 .2. | 185335 | -245623 | 4.071270 | 9711343 | 12 |
| | 2272179 233320 4-285947 9738439 52 29 -2 | -233320 4-285947 -9738439 52 29 -2 | 4.285947 9738439 52 29 -2 | 9738439 52 29 -2 | 52 29 -2 | 29 -2 | | 331625 | 239771 | 4-170644 | -9724378 | 314 | 9 .2 | 88159 | -245932 | 4.066164 | 9710649 | 11 |
| | 2275012 233627 4-280319 9737778 51 30 -2 | -233627 4-280319 -9737778 51 30 -2 | 4-280319 -9737778 51 30 -2 | 9737778 51 30 -2 | 5130 -2 | 30 -2 | | 334454 | 240078 | 4.165299 | -9722699 | 305 | 0 .2 | 186068 | -246240 | 4.061070 | -9709953 | 10 |
| | 2277844 -233934 4-274706 -9737116 50 31 -2: | -233934 4-274706 -9737116 50 31 -2: | 4-274706-9737116 50 31 -2: | 9737116 50 31 -2: | 5031 .2; | 31 .2: | 2.5 | 337282 | 240386 | 4-159968 | 9723020 | 295 | 1 .2: | 808868 | .2465'1 | 4-055987 | -9709258 | 6 |
| | 2280677 234241 4.269107 9736453 49 32 2 | 234241 4.269107 9736453 4932 2 | 4.269107 9736453 4932 2 | 9736453 49 32 2 | 49 32 2 | 32 2 | 25 | 340110 | 240694 | 4-154650 | 9722339 | 285 | 2 .2 | 889968 | 246857 | 4.050917 | 9708561 | 00 |
| | 2283509 234547 4.263521 9735789 4833 3 | -234547 4-263521 -9735789 48 33 -2 | 4.263521 9735789 4833 2 | 9735789 48 33 .2 | 48 33 .2 | 33 .2 | | 342938 | 241001 | 4.149344 | -9721658 | 275 | 3 .2 | 199457 | -247166 | 4.045859 | 9707863 | 1 |
| | 2286341 -234854 4-257950 -9735124 47 34 -2 | -234854 4-257950 -9735124 47 34 -2 | 4.257950 -9735124 47 34 -2 | 9735124 47 34 -2 | 47 34 -2 | 34 -2 | | 345766 | 241309 | 4.144051 | 9720976 | 265 | 4 .2 | 08220 | -247475 | 4-040812 | 9707165 | |
| | 2289172 -235161 4-252392 -9734458 46 35 -2. | -235161 4-252392 -9734458 46 35 -2: | 4.252392 -9734458 46 35 -2: | 9734458 46 35 -2: | 46 35 -2: | 35 -2 | 27 | 348594 | 211617 | 4-138771 | -9720294 | 255 | 5 -24 | 05104 | -247783 | 4-035777 | 9706466 | 100 |
| | 2292004 -235468 4.246848 -9733792 45 36 -2. | -235468 4.246848 9733792 45 36 ·2. | 4.246848 9733792 45 36 .2. | 9733792 45 36 -2. | 45 36 -2: | 36 -2 | 2.5 | 351421 | 241925 | 4-133504 | 9719610 | 245 | 6 .24 | 107927 | 248092 | 4-030755 | 9705766 | 4 |
| | 2294835 235775 4.241317 9733125 4437 2. | -235775 4-241317 9733125 44 37 -2: | 4.241317 9733125 44 37 .2: | 9733125 44 37 -2; | 44 37 .2 | 37 -2 | 27 | 354248 | 212233 | 4-128249 | 9718926 | 235 | 7.24 | 10751 | 248401 | 4-025744 | 9705065 | |
| | 2297666 236082 4.235800 9732457 43 38 -2; | -236082 4-235800 -9732457 43 38 -2; | 4.235800 9732457 43 38 -2; | 9732457 43 38 -2; | 43 38 -2; | 38 -2 | 200 | 357075 | 242541 | 4-123007 | 9718240 | 225 | 8 .9 | 13574 | 248710 | 4.020744 | 9704363 | |
| | 2300497 236390 4.230297 9731789 42 39 -23 | -236390 4-230297 -9731789 42 39 -25 | 4.230297 -9731789 42 39 -23 | 9731789 42 39 -23 | 42 39 -25 | 39 .25 | 4.0 | 1206698 | 242849 | 4-117778 | -9717554 | 215 | 91.2 | 16396 | -249019 | 4-015757 | -9703660 | 1 |
| Sine. / Cosine. Cotang. Tang. | $\cdot 2303328 \cdot 236697 \cdot 4 \cdot 224808 \cdot 9731119 \cdot 4140 \cdot 23$ $\cdot 2306159 \cdot 237004 \cdot 4 \cdot 219331 \cdot 9730449 \cdot 40$ | -236697 4-224808 -9731119 41 40 -23 -237004 4-219331 -9730449 40 | 4.224808 9731119 41 40 -23 4.219331 9730449 40 | -9731119 41 40 -23 | 41 40 .23 | 10 -23 | 45 | 62729 | 213157 | 4-112561 | 9716867 | 506 | 0.24 | 612611 | 249328 | 4.010780 | -9702957 | |
| Sine. ' Cosine. Cotang. Tang. | | | i | 1 | 1 | 1 | | 1 | | 1 | - | 1 | 1 | 1 | 1 | 1 | - | 1 |
| | Cosine, Cotang. Tang. Sine. / C. | Sine. | Sine. | - | , C | CC | 20 | osine. | Cotang. | Tang. | | | 0/ | osine. | Cotang. | Tang. | Sine. | - |

Deg. 75.

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| | F | 6 | 00 | 1 | 9 | 5 | 4 | 20 | 50 | - | 0 | 6 | 00 | - | 9 | 2 | 4 | 8 | 65 | - | 5 | T |
|---------|---------|---|---|--|---|---|--|--|---|--|---|--|--|--|--|--|--|--|---|---|--|-----------------------|
| | e. | 161 | _ | $-2424863 \cdot 249946 + 000863 \cdot 9701548 \\ \hline 58 \\ \hline 23 \cdot 2484081 \\ \hline \cdot 256446 \\ \hline 3\cdot899451 \\ \hline \cdot 9686555 \\ \hline 37 \\ \hline 43 \cdot 2540393 \\ \hline \cdot 26456 \\ \hline 3\cdot807260 \\ \hline \cdot 9671939 \\ \hline 17 \\ \hline 19 \cdot 9686555 \\ \hline 37 \\ \hline 43 \cdot 2540393 \\ \hline \cdot 264039 \\ \hline \cdot 264039 \\ \hline \cdot 364039 \\ \hline \cdot 364$ | 100 | _ | 181 | 771 | 2458971, 251491 , 3.976271 , 9698011 , 5328 , 2498167 , 257997 , 3876014 , 96882931 , 3248 , 2554458 , 264211 , 3.784848 , 9668234 , 12 | 1 06 | 46 1 | 01 | 22 | 80 | 19 | 12 | 89 | 13 | 29 | 111 | 863 | 1 |
| | Cosine. | 6734 | 6726 | 6719 | 6712 | 6704 | 9669718 | 6899 | 6682 | 6674 | 6667 | $252420[3.961651] \cdot 9695879[50] 31[2506616] \cdot 258928[3.862078] \cdot 9680748[29[51] \cdot 2562894[265145] \cdot 3771518[9666001] \cdot 3882001[3.96162] \cdot 3882001$ | 6652 | 53 2568517 265768 3.762680 9664508 | $\cdot 253348 \cdot 3\cdot 947133 \cdot 9693740 \cdot 4734 \cdot 2515063 \cdot 259859 \cdot 3\cdot 848235 \cdot 9678557 \cdot 2634 \cdot 2571328 \cdot 266079 \cdot 3\cdot 758276 \cdot 9663761 \cdot 2671328 \cdot 2671328 \cdot 266079 \cdot 3\cdot 758276 \cdot 9663761 \cdot 2671328 \cdot 2671328 \cdot 266079 \cdot 3\cdot 758276 \cdot 9663761 \cdot 2671328 \cdot 267128 \cdot 2671328 \cdot 267128 $ | 6630 | -9662263 | 2523508 260791 3-834486 9676358 2357 2579760 267014 3-745120 9661513 | 6607 | 6600 | 6592 | Sine |
| | - | 6.9 | 8.9 | 6-0 | 8 9 | 6.9 | 13 9 | 6.0 | 6: | 5 3 | 1.9 | 8.9 | 4 .9 | 6.0 | 6.9 | 11.9 | 6-9 | 6.0 | 4-9 | 6.8 | 6.0 | - |
| | Cotang. | 1629 | 1177 | 0726 | 0275 | 9856 | 9378 | 8931 | 8484 | 8038 | 7595 | 7151 | 6049 | 8929 | 5827 | 5388 | -2520694 -260480 3-839059 -9677092 24 56 -2576950 -266702 3-749496 | 1212 | 1075 | 3639 | 3205 | Cosine, Cotane, Tane. |
| | ၁ | 3.8 | 3.8 | 3.8 | 3.8 | 37 | 3.7 | 3.7 | 3.7 | 3.7 | 3.7 | 3-7 | 3.7 | 13.7 | 3.7 | 3.7. | 3.7 | 3.7 | 13.7 | 3.7 | 3.7 | - |
| | Tang. | 2034 | 2345 | 2656 | 2967 | 3278 | 3589 | 3900 | 1211 | 1522 | 1833 | 5145 | 5456 | 5768 | 8079 | 3390 | 3702 | 7014 | 7325 | 7637 | 7949 | HID |
| | Ta | .265 | .265 | 26 | -265 | .26 | .26 | .26 | -26 | -26 | .26 | .26 | .26 | .26 | 98. | -26 | .26 | .26 | .56 | .26 | .26 | Cot |
| | le. | 1766 | 1579 | 0393 | 3206 | 8019 | 8832 | 1645 | 1458 | 7270 | 0085 | 2894 | 5705 | 3517 | 1328 | 1139 | 9950 | 9760 | 2570 | 1889 | 3190 | ine. |
| 14 Deg. | Sine. | 253 | 2537 | 254 | 254: | 254 | 2548 | 255 | 255 | 255 | 256 | 2569 | 256 | 2568 | 257 | 257 | 257 | 257 | 258 | 258 | 2588 | Cos |
| 14 1 | _ | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 20 | 21 | 55 | 53 | 54 | 55 | 99 | 22 | 28 | 69 | 09 | 1 |
| | - | 8 39 | 7 38 | 5 37 | 2 36 | 8 35 | 3 34 | 8 33 | 1 32 | 4 31 | 6 30 | 8 29 | 8 28 | 8 27 | 7,26 | 5 25 | 2 24 | 8 25 | 4 22 | 8 21 | 2 20 | 1 |
| | Cosine. | 3799 | 3727 | 3655 | 3583 | 3510 | 3438 | 3365 | 3293 | 3220 | 3147 | 3074 | 3001 | 826 | 855 | 7782 | 604 | 632 | 1562 | 488 | 415 | Sino. |
| | | -968 | 396 | 396. | 396- | -968 | 396. | 396. | -968 | -968 | 396. | 396. | -968 | -96 | .96 | -967 | -96 | .96 | 196- | -967 | -96 | a. |
| | Cotang. | 1068 | 171 | 1451 | 1742 | 044 | 357 | 089 | 014 | 358 | 3713 | 8703 | 453 | 833 | 3235 | 1642 | 059 | 486 | 923 | 370 | 828 | 100 |
| | Cots | 306- | 1-904 | 368- | 1.894 | 1890 | 188 | 1.880 | 876 | 187 | 998. | 1.862 | 1-857 | 1-855 | 1.848 | 1.848 | 1838 | 1834 | 1.828 | 1.826 | 850 | Tang |
| | | 126 3 | 36 3 | 463 | 563 | 66 3 | 1763 | 863 | 97.3 | 07 3 | 17 3 | 28 3 | 38 3 | 483 | 159 3 | 69 3 | 80 3 | 91 3 | 013 | 123 | 23 | |
| | Tang. | 2558 | 2561 | 2564 | 2567 | 2570 | 2573 | 2576 | 2575 | 2588 | 2586 | 2589 | 2592 | 2595 | 2598 | 2601 | 2604 | 2607 | 2611 | 2614 | 2617 | otal |
| | | 45 | 63 | 181 | 668 | 91 | 33 | 150 | 67 | 84 | 000 | 919 | 32 | 48 | 63 | 179 | 94 | 80 | 23 | 37 | 52 | / Cosine Cotang |
| 5n | Sine. | 1784 | 1812 | 1840 | 1868 | 1897 | 1925 | 1953 | 1981 | 5009 | 5038 | 9909 | 5094 | 5122 | 5150 | 5178 | 5206 | 5235 | 5263 | 5291 | 5319 | Ocin |
| 14 Deg. | | 1.2 | 65 | 3 .2 | 4.2 | 5 -2 | 6 .2 | 7. | 3 | 9 .2 | 0 -2 | 12.5 | C.5 | 30 | 4 | 50 | 6 22 | 7 2 | 8 .2 | 8.6 | 0 | 10 |
| - | - | 602 | 592 | 582 | 57 2 | 562 | 55 2 | 542 | 532 | 522 | 513 | 503 | 493 | 483 | 473 | 463 | 453 | 443 | 433 | 423 | 414 | - |
| | ne. | 957 | 253 | 548 | 842 | 135 | 428 | 720 | 011 | 301 | 591 | 879 | 167 | 453 | 740 | 025 | 309 | 593 | 875 | 157 | 438 | 1 |
| | Cosine. | 1702 | 3702 | 1076 | 9700 | 9700 | 6696 | 8696 | 8696 | 1696 | 9696 | 9695 | 3695 | 9694 | 9693 | 9693 | 9695 | 1696 | 0696 | 0696 | 9689 | Sino |
| | - | 80 | 16 | 63 | 22 | 92 | 73 | 99 | 71 | 98 | 13 | 51 | 01 | 61 | 33 | 15 | 60 | 14 | 29 | 56 | 93 | 1 |
| | Cotang. | 1010 | 900 | 8000 | 9959 | 6066 | 9860 | 9811 | 3762 | 3713 | 3665 | 9616 | 9568 | 9519 | 1471 | 3423 | 3375 | 3327 | 3279 | 9231 | 9183 | Tona |
| | - | 8 4.0 | 7 4.0 | 6 4. | 5 3. | 4 3. | 3 3.6 | 2 3.5 | 13. | 1 3. | 0 3.5 | 0 3-6 | 9.8 | 8 3. | 8 3.5 | 8 3.6 | 7 3. | 7 3. | 7 3. | 6 3. | 6 3.9 | 15 |
| | Tang. | 932 | 8963 | 1994 | 5025 | 9909 | 7806 | 8118 | 5149 | 0819 | 5211 | 5242 | 5272 | 5303 | 5334 | 5365 | 3968 | 5427 | 9458 | 9489 | 5520 | ton |
| | T | 2419219 -249328 4.010780 9702957 6021 -2478445 -255826 3-908901 -9687998 -3941 -2534766 -222034 3-816295 -3973415 | 24922041 249637 4.005816 -9702253 592 2481263 -256136 3.904171 -9687277 5842 -2537579 -262345 3.811773 -9672678 | 3 .24 | $ \begin{array}{c} -2427685 - 250255 \\ 3 - 995922 \\ \end{array} \begin{array}{c} -9700842 \\ \end{array} \begin{array}{c} -57262 \\ \end{array} \begin{array}{c} -2486899 \\ \end{array} \begin{array}{c} -256756 \\ \end{array} \begin{array}{c} -3894742 \\ \end{array} \begin{array}{c} -9685832 \\ \end{array} \begin{array}{c} -3648742 \\ \end{array} \begin{array}{c} -364366 \\ \end{array} \begin{array}{c} -36466 \\ \end{array} \begin{array}{c} -364366 \\ \end{array} \begin{array}{c} -36466 \\ \end{array} \begin{array}{c} -364366 \\ \end{array} \begin{array}{c} -36466 \\ \end{array}$ | ·2430507 ·250564 3·990992 ·9700135 5625 ·2489716 ·257066 3·890044 ·9685108 35456 ·2546019 ·263278 3 798266 ·9670459 | $-2433329 \cdot 250873 \cdot 3\cdot986073 \cdot 9699428 \cdot 55 \cdot 26 \cdot 2492533 \cdot 257376 \cdot 3\cdot885357 \cdot 9684383 \cdot 34 \cdot 46 \cdot 2548832 \cdot 263589 \cdot 3\cdot793783 \cdot 3\cdot193783 \cdot 3\cdot19378 \cdot 3\cdot193$ | $-2436150 \cdot 251182 \cdot 3\cdot 981166 \cdot 9698720 \cdot 5427 \cdot 2495350 \cdot 257686 \cdot 3\cdot 880680 \cdot 9683658 \cdot 33 \cdot 47 \cdot 2551645 \cdot 263906 \cdot 3\cdot 789310 \cdot 9668977 \cdot 3551645 \cdot 263906 \cdot 3\cdot 789310 \cdot 9668977 \cdot 3551645 \cdot 35$ | 1.2 | $-2441792 - 251801 - 3\cdot971386 - 9697301 - 5229 - 2500984 - 258307 - 3\cdot871358 - 9682204 - 3149 - 2557270 - 264522 - 3\cdot780395 - 9667490 - 301737 - 3$ | $-2444613 - 252110 \cdot 3 -966513 -9696591 \cdot 51 \cdot 30 \cdot 2503800 \cdot 258617 \cdot 3 \cdot 866713 \cdot 9681476 \cdot 30 \cdot 50 \cdot 2560082 \cdot 264833 \cdot 3 \cdot 775951 \cdot 9666746 \cdot 3 \cdot $ | 3 .2 | 2450254 252729 3:956801 9695167 4932 2509432 2569438 3:857463 9680018 2852 2565705 265456 3:767094 9665255 | 2453074 253038 3-951961 -9694453 48 33 2512248 259548 3-852839 -9679288 27 | 4.2 | -2458713 - 253658 - 3 - 942315 - 9693026 - 4635 - 2517879 - 260169 - 3 - 843642 - 9677825 - 2656 - 2574139 - 266390 - 3753881 - 9663012 - 2458713 - 253658 - 2574139 - 266390 - 245871 - 2458712 - 2458713 - 245871 - 2458713 - 245871 - 24 | 2461533 253967 3-937509 9692309 45 36 | 2464352 254277 3932714 9691593 44 37 | 1 .2 | $2469990 \cdot 254896 \mid 3.923156 \cdot 9690157 \mid 42 \mid 39 \cdot 2529137 \cdot 261412 \mid 3.825370 \cdot 9674888 \cdot 21 \mid 59 \cdot 2585381 \cdot 267637 \mid 3.736398 \cdot 9660011 \cdot 2469990 \cdot 254896 \mid 3.925381 \cdot 267637 \mid 3.736398 \cdot 9660011 \cdot 267637 \mid 3.736398 \cdot 960011 \cdot 267637 \mid 3.73637 \mid 3.7367 \mid 3.7$ | 2472809 255206 3-918393 9689438 4140 2531952 261723 3-820828 9674152 2060 2588190 267949 3-722050 9659258 2475627 255516 3-913642 9688719 40 | Cosine Cotone |
| | Sine. | 921 | 204 | 486 | 894 | 020 | 1332 | 3615 | 1887 | 179 | 461 | -2447433 | 5025 | 307 | 588 | 11871 | 153 | 435 | 3717 | 666 | 280 | ouis |
| 14 Deg. | 30 | 241 | -242 | | | .243 | | .243 | .248 | | -244 | -244 | -245 | .245 | 3 -2455894 | -245 | .24€ | -246 | -2467171 -254587 $-3-92999$ -9690875 -4388 -2526323 -261101 $-3-829923$ -9675624 -228 -2582570 -267325 $-3-740754$ -9660762 | -246 | 247 | 2 |
| 14 | - 1 | 0 | - | 01 | 89 | 4 | 0 | 9 | 2 | 000 | 6 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 10 | 1 |

| 1147 274507 3642891 9643268 39 1952 274820 3653874 9643268 39 1952 274820 3653874 9643268 39 15561 275445 3630477 9640954 36 1366 275758 362356 9640181 35 1170 2766071 3622244 9639407 34 1377 276381 361940 9637681 31 1384 2777 276011 3609960 9637081 31 1384 27773 4 360588 963580 32 1589 277761 4 963526 9633969 27 1989 277851 3597659 9633969 22 1989 277851 3597659 9633189 26 1989 277851 3597659 9633189 26 1989 277851 3597659 9633189 26 1989 277851 3597659 9633189 26 1989 277851 3597659 9633189 26 1989 278578 3589659 9630060 22 1000 279831 3557579 9630060 22 1000 279832 3573569 9630060 22 1000 279832 3573569 9629275 21 | | | 0 | - | | | - | | - | - | - | , | * | | • • | 2.0.1 | | -, | - | - | | | | | - |
|--|---|---------|------------|-----------|-----------|------------|------------|-----------|-----------|----------|-----------|-----------|------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|----------|-------------------|----------|
| | F | - | 19 | - | 17 | 16 | 15 | 14 | | 12 | 11 | 10 | 6 | 00 | 7 | 9 | 2 | 4 | 00 | C.S | - | 0 | 1 | - | 4. |
| | | Cosine. | 627704 | 1626917 | 0819790 | 625342 | 624552 | 1623762 | 822972 | 622180 | 1621387 | 620594 | 0086196 | 9006196 | 618210 | 617413 | 9199196 | 818919 | 610919 | 9614219 | 613418 | 192196 | | Sine. | Deg. 74. |
| | | Cotang. | -561590 -6 | 557613 | 553644 6 | ·549684 ·8 | -545732 -6 | 541788 | 537852 - | -533925 | 530005 | -526093 - | -522190 -6 | 518294 | 514407 | 510527 | 506655 | 502791 -6 | 498935 | 495087 | 491247 | 487414 | | Tang. | |
| | | | 2807733 | 281087 3 | 2814013 | 2817153 | 282029 3 | 282343 3 | 282657 3 | 282971 3 | 283285 3 | 283599 3 | 283914 3 | 284228 3 | 284543 3 | 284857 3 | 285172 3 | 285486 3 | 285801 3 | 286115 3 | 286430 3 | 286745 3 | | _ | |
| | | Sine. | 2703204 | 2706004 | 2708805 | 2711605 | 2714404 | 2717204 | 2720003 | 2722802 | 2725601 | 2728400 | 2731198 | 2733997 | 2736794 | 2739592 | 2742390 | 2745187 | 2747984 | 2750781 | 2753577 | 2756374 | | Cosine. Cotang. | |
| | 1 | | 041 | 842 | 743 | 644 | 545 | 446 | 347 | 248 | 149 | 050 | 951 | 8 52 | 753 | 654 | 5 55 | 1 26 | 357 | 258 | 1 59 | 090 | | 1 1 | |
| | | Cosine. | 9643268 3 | 9642497 3 | 9641726 3 | 9640954 3 | 9640181 3 | 9639407 3 | 9638633 3 | 96378583 | 9637081 3 | 9636305 3 | 9635527 2 | 9634748 2 | 9633969 2 | 9633189 2 | 9632408 2 | 9631626 | 9630843 2 | 9630060 2 | 9629275 2 | 9628490 2 | | Sine. / | Deg. 74. |
| | | | 3-642891 | 3-638744 | 3-634606 | 3.630477 | 3.626356 | 3.622244 | 3.618141 | 3-614046 | 3-609960 | 3-605883 | 3-601814 | 3-597754 | 3-593702 | 3-589659 | 3.585624 | 3.581597 | 3-577579 | 3-573569 | 3-569568 | 3-565574 | | Tang. | |
| | | Tang. | -274507 | 274820 | 275133 | 275445 | 275758 | 276071 | 276385 | 869912 | 110772 | 277324 | 277637 | 277951 | 278264 | 278578 | 278891 | 279205 | 812612 | 279832 | 280145 | 280459 | | Cotang. | |
| | | Sine. | -2647147 | 2649952 | 2652757 | 1999999 | 9988997 | 2661170 | 2663973 | 2666777 | 2669581 | 2672384 | 2675187 | 68617989 | 2680792 | 2683594 | 2686396 | 8616897 | 2692000 | 2694801 | 2697602 | 2700403 | | ' Cosine. Cotang. | |
| | | | 21 | 55 | 23 | 24 | 25 | 56 | 27 | 28 | 53 | 30 | 31 | 35 | 33 | 34 | 35 | 98 | 37 | 38 | 39 | 40 | | - | Н |
| | 1 | - | 8 60 | 5 59 | 1 58 | 3 57 | 99 | 155 | 3 54 | 3 53 | 9 52 | 151 | 9 50 | 49 | 148 | 247 | 3 46 | 3 45 | 3 44 | 143 | 1 42 | 341 | 7 40 | - | 4 |
| | | | 965925 | 965850 | 965775 | -965699 | 965624 | 965548 | 965472 | -9623968 | 9653209 | 965244 | 9651689 | -9650927 | 965016 | 9649405 | 9648638 | 964787 | 9647108 | 964634 | 964557 | 964480 | 964403 | Sine. | Deg. 74. |
| | | Cotang. | 3-732050 | 3-727713 | 3.723384 | 3-719065 | 3-714756 | 3-710455 | 3-706164 | 3-701883 | 3-697610 | 3.693346 | 3.689092 | 3.684847 | 3.680611 | 3-676384 | 3-672166 | 3-667957 | 3-663757 | 3-659566 | 3-655384 | 3-651211 | 3.647046 | Tang. | |
| | | Tang. | 267949 | 268261 | 268572 | -268884 | 961692 | -269508 | .269820 | -270132 | -270444 | -270757 | -271069 | 271381 | -271694 | -272006 | -272318 | -272631 | -272943 | -273256 | -273569 | 273881 | -274194 | Cotang. | |
| | 0 | Sine. | 2588190 | 2591000 | 2593810 | 2556619 | 2599428 | 2602237 | 2605045 | 2607853 | 2610662 | 2613469 | 2616277 | 2619085 | 2681292 | 2624699 | 2627506 | 2630312 | 2633118 | 2635925 | 2638730 | 2641536 | 2644342 | Cosine. Cotang. | |
| | | - | 0 | 1 | es. | 3 | + | 5 | 9 | 7 | 00 | 6 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 180 | 19 | 0% | 1- | 7 |

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|---------|---------------------------|--|--|--|--|--|--|--|--|---|---|---|--|---|--|--|--|--|---|---|--|----|-------------------------|
| | Cosine. | 9579060 | 9578225 | -9577389 | -9576552 | 9575714 | 9574875 | 9574035 | 9573195 | -9572354 | 9571512 | -9570669 | -9569825 | 1868996 | 9568136 | -9567290 | 9566443 | 9565595 | -9564747 | -9563898 | -9563048 | 1 | Sine. |
| | Tang. Cotang. | 3-336699 | 3-333173 | 3.329654 | 3-326141 | 3-322636 | 3-319137 | 3-315645 | 3.312159 | 3.308681 | 3.305209 | 3-301743 | 3.298285 | 3.294833 | 3-291387 | 3.287948 | 3.284516 | 3.281090 | 3-277671 | 3.274258 | 3-270852 | 1 | Tang. |
| | Tang. | 299692 | 300014 | -300331 | 300648 | 300965 | 301283 | 301600 | 301917 | 302235 | 302552 | .302870 | 303187 | 303505 | 303823 | 304141 | 304458 | 304776 | 305094 | 305412 | 305730 | | Cotang. |
| 16 Deg. | Sine. | 2870819 | 2873605 | 2876391 | 2879177 | 2881963 | 2884748 | 2887533 | -2890318 | 2893103 | 2895887 | 17898671 | 2901455 | 2904239 | 2907022 | 2909805 | 2912588 | 2915371 | 2918153 | 2920935 | 2923717 | 1 | / Cosine. Cotang. Tang. |
| 191 | - | 15 | 122 | 13 | VI | 45 | 46 | 47 | 8 | 64 | 20 | 19 | 25 | 53 | 54 | 55 | 99 | 57 | 58 | 169 | 09 | 1 | - |
| | - | 39 | 38 | 37 | 36 | 35 | 34 | 33 | 32 | 31 | 30 | 53 | 28 | 27 | 26 | 52 | 24 | 533 | 55 | 21 | 20 | | - |
| | Tang. Cotang. Cosine. | 0-2756374 286745 3-487414 -9612617 6021 -2815042 -293368 3-408688 -9595600 3941 -2870819 -299687 3-336699 -9579060 | $2759170 \cdot 287060 \cdot 3483589 \cdot 9611815 \cdot 59 \cdot 22 \cdot 2817833 \cdot 293683 \cdot 3405021 \cdot 9594781 \cdot 3842 \cdot 2873605 \cdot 300014 \cdot 3333173 \cdot 957825 \cdot 2873605 \cdot 300014 \cdot 3333173 \cdot 957825 \cdot 3873605 \cdot 387$ | *2761965 *287375 3 479772 9611012 5823 *2820624 *293999 3 401361 *9593961 37 143 *2876391 *300331 3 *329654 *9577389 | -2764761 - 287690 - 3-475968 - 9610208 - 5724 - 2823415 - 294316 - 3-397708 - 9593140 - 3614 - 2879177 - 300648 - 3-326141 - 9576552 - 3764761 - 3676552 - 3764761 - 3676552 - 3764761 - 3676576 - 3764761 - 3676576 - 3764761 - | 2767556 288005 3-472161 -9609403 5625 2826205 294632 3-394063 9592318 3545 2881963 300965 3-322636 9575714 | $\cdot 2770352 \cdot 288320 \mid 3 \cdot 468367 \cdot 9608598 \mid 55 \mid 26 \cdot 2828995 \cdot 294948 \mid 3 \cdot 390424 \mid 9591496 \mid 34146 \cdot 2884748 \mid 301283 \mid 3 \cdot 319137 \mid 9574875 \mid 9$ | $\cdot 2773147 \cdot 288635 \cdot 3464581 \cdot 9607792 \cdot 5427 \cdot 2831785 \cdot 295264 \cdot 3\cdot386793 \cdot 9590672 \cdot 3347 \cdot 2887533 \cdot 301600 \cdot 3\cdot315645 \cdot 9574035 \cdot 301600 \cdot 3\cdot315645 \cdot 9574035 \cdot 301600 \cdot 3\cdot315645 \cdot 9574035 \cdot 301600 \cdot 3\cdot315645 \cdot 301600 \cdot 3016000 \cdot 30160000 \cdot 30160000 \cdot 30160000 \cdot 30160000 \cdot 30160000 \cdot 301600000 \cdot 301600000 \cdot 301600000 \cdot 3016000000 \cdot 3016000000 \cdot 301600000000000000000000000000000000000$ | $-2775941 - 288950 \ 3 - 460802 - 9606984 \ 5328 - 2834575 - 295580 \ 3 - 383169 - 9689848 \ 3218 - 2890318 - 301917 \ 3 - 312159 \ 9573195 \ 3 - 312159 \ 3 - 3$ | ·2778736 ·289265 (3-457031 ·9606177 52/29 ·2837364 ·295897 3-379553 ·9589023 31 49 ·2893103 ·302235 3-308681 ·9572354 | $-2781530 -289580 \ \ 3+53267 -9605368 \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \$ | $-2784324 - 289896 \mid 3-449512 \mid -9604558 \mid 50 \mid 31 \mid -2842942 \mid -2842942 \mid -295529 \mid 3-372340 \mid -9587371 \mid 29 \mid 51 \mid -2898671 \mid -302870 \mid 3-301743 \mid -9570669 \mid -289896 \mid -289896 \mid -2898671 \mid -302870 \mid -2898671 \mid -289867$ | -2787118 - 290211 - 3-445763 - 9603748 + 49 = 32 - 2845731 - 296846 - 3-368745 - 9586543 - 2852 - 2901455 - 303187 - 3-298285 - 9569825 - 2087118 - 208785 - 208787 - 208785 - 208785 - 208785 - 208787 - 208785 - 208785 - 208785 - 208785 - 208785 - 208787 - 208785 - 208785 - 208785 - 208785 - 208785 - 208785 - 208787 - 208785 | 2 -2789911 -290526 3-442022 -9602937 4833 -2848520 -297163 3 365156 -9585715 2753 -2904239 -303505 3-294833 -950898 | $3 \cdot 2792704 \cdot 290842 \cdot 3 \cdot 438289 \cdot 9602125 \cdot 4734 \cdot 2851308 \cdot 297479 \cdot 3 \cdot 361575 \cdot 9584886 \cdot 2654 \cdot 2907022 \cdot 303823 \cdot 3 \cdot 291387 \cdot 9568136 \cdot 202120 \cdot 2$ | $4 \cdot 2795497 \cdot 291157 \cdot 3434563 \cdot 9601312 \cdot 46 \cdot 35 \cdot 2854096 \cdot 297796 \cdot 3358000 \cdot 9584056 \cdot 2555 \cdot 2909805 \cdot 304141 \cdot 3287948 \cdot 9567290 \cdot 9607290 \cdot 960720 \cdot 9607290 \cdot 960720 \cdot $ | $5.2798290 \cdot 291473 \cdot 3.430841 \cdot 9600499 \cdot 4536 \cdot 2856884 \cdot 298112 \cdot 3.564433 \cdot 9583226 \cdot 2456 \cdot 2912588 \cdot 304458 \cdot 3.284516 \cdot 9566443 \cdot 2.2798290 \cdot 2912588 \cdot 304458 \cdot 3.284516 \cdot 9566443 \cdot 2.2798290 \cdot 2912588 \cdot 304458 \cdot 3.284516 \cdot$ | $6 \cdot 2801083 \cdot 291789 \cdot 3427153 \cdot 9599684 \cdot 44 \cdot 37 \cdot 2859671 \cdot 298429 \cdot 3 \cdot 350872 \cdot 9582394 \cdot 2357 \cdot 2915371 \cdot 304776 \cdot 3281090 \cdot 9565595 \cdot 3281090 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 3281000 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 3281000 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 3281000 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 3281000 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 3281000 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 3281000 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 3281000 \cdot 328100 \cdot 328100 \cdot 328100 \cdot 3281000 \cdot 32810000 \cdot 3281000 \cdot 3281000 \cdot 3281000 \cdot 32810000 \cdot 3281000 \cdot 32810000 \cdot 32810000 \cdot 32810000 \cdot 32$ | $7 \cdot 2803875 \cdot 292104$ $3 \cdot 423429 \cdot 9598869$ $43 \cdot 38 \cdot 2862458 \cdot 298746$ $3 \cdot 347319 \cdot 9581662$ $22 \cdot 58 \cdot 2918153 \cdot 305094$ $3 \cdot 277671 \cdot 9564747$ | 8 2806667 292420 3-419733 9598053 42 39 2865246 299063 3-343772 9580729 21 59 2920935 305412 3-274258 9563898 | $\begin{array}{c} 19 \cdot 2809459 \cdot 292736 \mid 3 \cdot 416044 \cdot 9597236 \mid 41604 \cdot 9597236 \mid 3 \cdot 340232 \cdot 9579895 \mid 2060 \cdot 2923717 \cdot 305730 \mid 3 \cdot 270852 \cdot 9563048 \\ 20 \cdot 2812251 \cdot 293052 \mid 3 \cdot 412362 \cdot 9596418 \mid 40 \\ \end{array}$ | | Sine. |
| | Cotang. | 3-408688 | 3-405021 | 3-401361 | 3.397708 | 3.394063 | 3-390424 | 3.386793 | 3-383169 | 3-379553 | 3.375943 | 3-372340 | 3.368745 | 3 365156 | 3-361575 | 3.358000 | 3.354433 | 3-350872 | 3-347319 | 3-343772 | 3-340232 | 1 | Tang. |
| | Tang. | -293368 | -293683 | -293999 | -294316 | -294632 | -294948 | -295264 | -295580 | ·295897 | -296213 | -296529 | -296846 | -297163 | -297479 | -297796 | 298112 | -298429 | -298746 | -299063 | -299380 | | Cotang. |
| 16 Deg. | Sine. | 2815042 | 2817833 | -2820624 | -2823415 | 2826205 | -2828995 | 2831785 | -2834575 | -2837364 | -2840153 | -2842942 | -2845731 | -2848520 | 2851338 | 2854096 | 2856884 | .2859671 | -2862458 | 2865246 | 2868032 | - | / Cosine. Cotang. Tang. |
| 16 | - | 22 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 35 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 1 | - |
| | - | 60 | 59 | 58 | 57 | 56 | 55 | 54 | 53 | 52 | 51 | 50 | 49 | 48 | 47 | 46 | 45 | 44 | 43 | 3 | 41 | | |
| | Cosine. | -9612617 | -9611815 | 9611012 | -9610208 | -9609403 | 9608598 | 9607792 | ·9606984 | -9606177 | 9605368 | -9604558 | -9603748 | -9602937 | 9602125 | 9601312 | 9600499 | -9599684 | 9598869 | -9598053 | 9597236 | 1 | Sine. |
| | Tang. Cotang. Cosine. | 3-487414 | 3-483589 | 3-479772 | 3-475963 | 3-472161 | 3-468367 | 3-464581 | 3-460802 | 3-457031 | 3-453267 | 3-449512 | 3-445763 | 3-442022 | 3-438289 | 3-434563 | 3-430844 | 3-427153 | 3.423429 | 3-419733 | 19 2809459 292736 3-416044 9597236 41 20 2812251 293052 3-412362 9596418 40 | | Tang. |
| | Tang. | -286745 | .287060 | 287375 | .287690 | -288005 | .288320 | -288635 | .288950 | -289265 | -289580 | -289896 | -290211 | -290526 | -290842 | -291157 | -291473 | -291789 | .292104 | -292420 | -292736 | | Cotang. |
| 16 Deg. | Sine. | 2756374 | 2759170 | -2761965 | 2764761 | -2767556 | 27770352 | -2773147 | 2775941 | .2778736 | -2781530 | 2784324 | -2787118 | 2789911 | -2792704 | 2795497 | -2798290 | 2801083 | -2803875 | 2806667 | -2812251 | | Cosine. Cotang. Tang. |
| 91 | - | 0 | - | C.S. | 8 | 4 | 5 | 9 | 7 | 00 | 6 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 13 | 1 | |
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| Sine, Tang. Cotang. Cosine. Sine, Tang. Cotang. Cosine. |
| Sine, Tang. Cotang. Cosine, Sine, Tang. Cotang. |
| Sine. Tang. Cotang. Cosine. Sine. Tang. 1-2926199 33-270852 9563048 6021 2982079 312422 1-2926199 306048 3-267452 9562197 582-2984556 312742 2-2929280 306367 3-264059 9561345 5822 2987652 313061 4-2934642 307003 3-257292 9559689 5625 2993184 313361 4-2934642 3077640 3-25529 955986 5427 2998569 31020 5-2937623 307723 3-255918 9558785 5526 2993184 314339 7-2943183 3077640 3-25529 9557930 5427 29985794 314539 7-2943183 307529 3-240486 9556361 5130 3007058 315298 10-29548743 308595 3-240486 9555361 5130 3007058 315298 11-2954302 309870 3-23143 955402 5031 3016308 316578 12-2957319 309870 3-227154 9551084 4833 3016380 316578 14-2962638 310189 3-22556 9551994 4333 3016380 316578 15-29573749 311146 3-219628 95545741 4140 3023699 318298 17-297691 311146 3-210630 9545608 4239 3022944 3183788 18-2973749 311146 3-210630 9545743 4140 3034788 318499 19-295628 311784 3-207344 9546743 4140 3034788 318499 19-295628 311784 3-207344 455786 4140 3034788 318499 19-295628 311784 3-207344 4140 3034788 318499 19-295628 311784 3-207344 4140 3034788 318499 19-295628 311784 3-207344 4140 3034788 318499 19-295628 311784 3-207344 4140 3034788 318499 19-295628 311784 3-207344 4140 3034788 318499 19-295628 311784 3-207344 4140 3034788 318499 19-295628 311784 3-207344 4140 3034788 318499 19-295628 311784 3-207344 4140 3034788 318499 19-2973749 311146 3-207344 4140 3034788 318499 19-295628 311784 3-207344 4140 3034788 318499 19-295628 311784 3-207344 31828 318499 19-295628 311784 3-207344 31828 318488 318489 19-295628 31858 318588 318588 318499 318588 318588 318588 318588 318588 |
| Sine. Tang. Cotang. Cosine. Sine. Sine. 2.292321717 -305730 3-270852 9563048 60 21 -2382079 1 -2926499 300648 3-270752 956292 956234 52 2994856 3 -29926499 300648 3-2674059 9561345 56 25 -2999184 5 -29936280 -306672 9569184 56 25 -2999184 5 -29936280 -306729 -3558918 9558765 55 26 -2999593 4 -2994842 -307003 3-257292 -9559699 56 25 -2999184 5 -29940403 -3077640 3-25050 -9558785 55 26 -29998734 7 -2940403 -3077640 3-25050 -9558785 55 26 -29998734 7 -294133 -307640 3-25050 -9558764 5 2 2 3 3004284 9 -2948743 -308595 3-244486 -9555861 51 30 -3007058 11 -2954893 -309233 3-233907 -9553643 49 32 -3015380 11 -2954893 -309233 3-233807 -9553643 49 32 -3015380 11 -2954893 -309233 3-23837 -9551024 63 5-3026926 11 -295688 -310689 3-227154 -9551924 47 34 -3018153 14 -2962688 -310689 3-227152 1 -954936 44 37 -3026471 17 -2970971 -311146 3-21722 1 -954936 44 37 -302647 18 -2973749 -311465 3-210630 -9545643 41 40 -3034788 20 -2973749 -311465 3-207344 -9546743 41 40 -3034788 -297556 -301630 -9545877 4 -297692 -201630 -2545877 4 -297692 -201630 -2545877 4 -297692 -201630 -2545877 4 -297692 -201630 -2545877 4 -297692 -201630 -2545877 4 -297692 -201630 -201630 -2545877 4 -297692 -201630 -2545877 4 -297692 -201630 -201630 -2545877 4 -201630 -2545877 4 -201630 -2545877 4 -201630 -2545877 4 -201630 -2545877 4 -201630 -2545877 4 -201630 -2545877 4 -201630 -2545877 4 -201630 -2545877 4 -201630 -2545877 4 -201630 -2545877 4 -201630 -2545877 4 -201630 -2545877 4 -201630 -2545877 4 -201630 -2545877 4 -201630 -2545877 4 -201630 -2545877 4 -201630 -2545877 4 -201630 -254587 4 -2016 |
| Sine. Tang. Cotang. Cosine. (178) 0.2923717 - 305739 |
| Sine. Tang. Cotang. Cosine. / 1.2926499 306748 3-270852 9563048 60 1-29264928 3-292928 9566499 3066678 3-266752 9563145 58 3-2932661 306685 3-266672 9565145 58 55 6-2940403 307640 3-257292 95559639 56 5-2940403 307640 3-25550 955785 55 6-2940403 307640 3-25550 955785 55 6-2946403 307640 3-25550 955785 55 6-294623 307640 3-25550 955785 55 6-294623 307640 3-25550 955704 58 2948743 307595 3-240486 9555361 51 10-2954302 308295 3-2320478 9555402 40 12-2957081 308295 3-2327143 9555402 46 13-2962638 310189 3-220526 9550199 45 15-2967081 31146 3-232626 95547608 42 117-2976516 3-2006463 9547608 42 119-2976526 3-210630 9547608 42 119-2976526 3-210630 9547608 42 119-2976526 3-210630 9547608 42 119-2976526 3-210630 9545608 42 119-2976526 3-210630 9545608 42 119-2976526 3-210630 9545608 42 119-2976526 3-210630 9545608 42 119-2976526 3-210630 9545608 42 119-2976526 3-210630 9545608 42 119-2976526 3-210630 9545743 41 110-2976526 3-210630 9545743 41 110-2976526 3-210630 9545743 41 110-2976526 3-210630 9545743 41 110-2976526 3-210630 9545743 41 110-2976526 3-210630 9545743 41 110-2976526 3-210630 9545743 41 110-2976526 3-210630 9545743 41 110-2976526 3-210630 9545743 41 110-206420 3-204063 9545743 41 110-20 |
| Sine. Tang. Cotang. Cosine. -2923717 -305730 3-270852 9563048 -2929280 306048 3-267452 95651345 -2934842 306367 3-2564059 95661345 -2934842 307036 3-257292 95560498 -2934842 307036 3-257292 95560498 -2934842 307036 3-237189 9556788 -2948743 307958 3-247189 9556731 -2948743 308595 3-240486 9555361 -2957813 308595 3-240486 9555784 -2957813 308596 3-220486 9555784 -2957813 309551 3-230478 9555784 -2957813 310487 3-220526 9550199 -2968194 310427 3-217221 9549308 -2968194 310427 3-217221 9549308 -296828 311784 3-207344 9545464 -296828 311784 3-207344 9545878 -2978919 311146 3-200636 9545876 -29799308 312103 3-204063 9545876 -29799309 312103 3-204063 9545876 -29799309 312103 3-204063 9545876 -2979900 3-204063 3-2546474 -297626 3-2070663 3-254674 -2979900 3-204063 3-254674 -297890 3-204063 3-254674 -297890 3-204063 3-254674 -297890 3-204063 3-254674 -297890 3-204063 3-254674 -297890 3-204063 3-254674 -297890 3-204063 3-254674 -206810 3-204063 3-254674 -206810 3-204063 3-254674 -206810 3-204063 3-25487 -206810 3-204063 3-25487 -206810 3-204063 3-25487 -206810 3-204063 3-25487 -206810 3-204063 3-25487 -206810 3-204063 3-25487 -206810 3-204063 3-25487 -206810 3-204063 3-25487 -206810 3-204063 3-25487 -206810 3-204063 3-25487 -206810 3-204063 3-25487 -206810 3-204063 3-25487 -206810 3-204063 3-25487 -206810 3-204063 3-25487 -206810 3-204063 3-25487 -206810 3-204063 3-25487 -206810 3-204063 3-26487 -206810 3-204063 3-26487 -206810 3-204063 3-26487 -206810 3-204063 3-26487 -206810 3-204063 3-26487 -206810 3-204063 3-26487 -206810 3-204063 3-26487 -206810 3-204063 3-26487 -206810 3-204063 3-26 |
| Sine. Tang. Cotang. |
| Sine. Tang. 1.2926199 306048 1.2926199 306048 1.292619 306046 4.2934842 307003 5.2937823 307540 1.2954842 307941 307958 1.295781 308595 11.295781 308595 11.295781 308595 11.295781 308595 11.295781 308595 11.295781 308595 11.295781 309551 11.2956859 309551 11.29568 3 |
| Sine. 0.2923717 1.2926499 2.29329280 3.2932061 4.2934842 5.2937623 7.2940403 7.2940403 1.29545963 1.29545963 1.29545963 1.29545963 1.29545963 1.29545963 1.29545963 1.29545963 1.29545963 1.29545963 1.29545963 1.29545963 1.29545963 1.29545963 1.29545963 1.29545963 1.29545963 1.2956516 1.2956516 1.2956516 1.2956516 1.2956519 |
| - 0 - 0 0 4 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 |
| |

Deg. 71.

Deg. 71.

Deg. 71.

| | ne. | 033 189 170 171 170 171 170 171 170 171 170 171 170 171 171 171 171 171 171 171 171 171 171 | T |
|---------|---------------------------|--|---------------|
| | g. Cosine. | 2-957205 94473035 2-954372 9472103 2-951545 9471170 2-942302 9465301 2-942302 9465493 2-942309 946555 2-931888 9465493 2-92099 9465555 2-931888 9465179 2-926315 9462736 2-926315 9462736 2-926315 9462736 2-926315 9462736 2-926315 9462736 2-926315 9462736 2-926315 9462736 2-926315 9462736 2-926315 9462736 2-926315 9462736 2-915225 9458968 2-915226 9458968 2-916226 9458023 | 1 |
| | Cotang. | 7 295732 7 295732 7 295732 7 295732 7 29573 7 29573 | 1 |
| | Tang. | 4.3815 0.33848 0.33848 0.33912 5.33945 5.33945 1.34048 1.34048 1.34140 0.34173 0.3436 0.3436 0.3436 0.3436 0.3436 0.3436 0.3436 0.3436 0.3436 0.3436 | 1 |
| 18 Deg. | Sine. | 320937, 320613 320613 321164 321164 321714 32261 32261 32361 32317 324167 324167 324167 324167 324167 324167 324167 324167 324167 324167 324167 | 1 |
| -8 | 1, | 23 | 1 |
| | Cosine. | 21 -3148209 -331686 3-014892 -9491511 3941 -3203374 -338157 2-957205 -9472103 22 -3150969 -332209 3-011960 -9499595 3842 -3206130 -338481 2-95472 -9472103 24 -3156490 -332255 3-000903 -9488760 3644 -3211640 -339129 2-948722 -9471170 24 -3156490 -332256 3-000110 -9488760 3644 -3211640 -339129 2-948722 -9471170 25 -3156490 -332278 3-003193 -9488760 3644 -3211640 -339129 2-948722 -9471170 25 -3156490 -332278 3-003193 -9488760 3644 -3211749 -339778 2-943092 -9468360 27 -316470 -333802 3-090028 -948760 344 -3219903 -340103 2-940284 -9467430 28 -3176288 -333948 2-991776 -9485081 -3248 -3228164 -341077 2-931888 -9465461 29 -3170288 -333477 -3948600 3749 -3228164 -341077 2-931888 -94651655 31 -3175805 -334918 2-988656 -9482313 2951 -3233670 -341726 2-92699 -9465365 31 -3175805 -334918 2-988040 -9480464 2753 -323670 -341726 2-92699 -9465854 31 -3175805 -335666 2-980040 -9490464 2753 -323672 -2917990 -9458968 33 -3189593 -335889 2-974301 -947881 2-556 -32344678 -343026 2-91526 -9458968 37 -3189593 -336537 2-97430 -947851 2-558 -3250917 -341407 2-91246 -9458968 37 -3189593 -33681 2-96853 -947766 -2357 -3244678 -343026 2-912464 -9456132 38 -3195106 -338861 2-96853 -947766 2-358 -323677 2-992788 -9456132 38 -3195106 -338861 2-96853 -947766 2-358 -323617 -344002 2-906957 -9456138 39 -3197883 -2960042 -9478997 2159 -3252931 -344002 2-906957 -9456188 | 10 |
| | Tang. Cotang. Cosine. | 3-011892 3-011960 3-0011960 3-005110 3-005110 3-003193 3-003193 2-9947375 2-9947375 2-9957375 2-982916 2-9743016 2-9743018 2-9743018 2-968583 2-968583 2-968583 2-968583 2-968583 2-968583 | Th |
| | Tang. | 331686 332009 332055 332076 333307 333427 334271 33450 33566 33566 33566 33566 33586 33687 33687 33687 33687 33687 33687 33687 | Charles |
| 18 Deg. | Sine. | 3148209 3150969 3155490 3155490 3155490 3155490 316240 3162520 3162520 3170288 3170688 3186896 3186896 3186896 3186896 3186896 3189269 3197666 | Chains Canna |
| 18 | , 1, | 7.8.8.4.8.8.4.8.8.4.8.8.4.8.8.4.8.8.4.8.8.4.8.8.4.8.8.8.4.8 | 1 |
| | Cosine. | 0 3090170 324919 30077683 9510565 6(21 3148209 332609 3011960 9490595 8842 3206180 338481 295272 4472103 | O. D. |
| | Cotang. | 3-077683 3-074640 3-074640 3-065542 3-065542 3-065542 3-065492 3-055487 3-05496 3-047491 3-047491 3-047491 3-047491 3-047491 3-047491 3-032535 3-032535 3-032535 3-032535 3-032535 3-032772 3-03772 | Thone |
| | Tang. | 924919 925541 925563 925563 926528 926528 927172 927174 927184 927184 928128 92 | Cosine Cotang |
| 18 Deg. | Sine. | 2.3090170 324919 1.3092936 325241 2.3094670 325884 4.3101234 325886 5.310399 326528 6.310764 327474 7.3109529 327172 8.3112294 327474 9.311658 327476 9.311658 327818 11.312036 3228461 13.312036 32876 14.3123875 329428 15.31233440 3329750 16.313440 3329750 16.313440 330073 18.313925 330073 18.313925 330073 18.313925 330073 19.3142886 331041 | Cosine |
| 81 | - 1 | 200840000000000000000000000000000000000 | 1. |

| | | 12 | LDI | ıE | V. | | 100 | E | , | - | 24.4 | 10 | | 200 | ,00, | | 21 | | | | • | 10 |
|---------|---------------------------|---|--|--|--|--|--|--|---|--|--|--|---|--|--|--|--|--|--|--------------------------------------|-------------------|----------|
| 1 | - | 61 | | | 15 | 13 | 12 | 11 | 10 | 6 | 00 | 1 | 9 | 2 | 4 | 3 | 27 | 1 | 0 | | - | 0 |
| | Tang. Cotang. Cosine. | -9415686 | 9413724 | 9412743 | 9411760 | .9409793 | 9408808 | -9407822 | -9406835 | .9405848 | -9404860 | -9403871 | -9402881 | -9401891 | -9400899 | -9399907 | .9398914 | 19397921 | -9396926 | | Sine. | Deg. 70 |
| | Cotang. | 2.795453 | 2.790333 | 2.787780 | 2.785230 | 2.780144 | 2-777606 | 2-775073 | 2.772544 | 2-770019 | 2-767499 | 2.764982 | 2.762469 | 2-759960 | 2.757456 | 2.754955 | 2.752458 | 2.749966 | 2-747477 | | Tang. | |
| | Tang. | .9597723 | 358380 | -358708 | -359036 | -359693 | 360022 | -360350 | 360679 | -361008 | -361337 | 361666 | -361994 | .362324 | -362653 | 362982 | -363311 | 363640 | 363970 | | Cotang | |
| 19 Deg. | Sine. | 3368214 | 3373691 | -3376429 | 3379167 | 3384642 | 3387379 | 33390116 | 3392852 | -3395589 | 3398325 | 3401060 | 3403796 | 3406531 | 3409265 | -3412000 | 3414734 | 3417468 | 3420201 | | / Cosine. Cotang. | |
| 19 | | 9 41 | 743 | 644 | 545 | 347 | 248 | 149 | 020 | 951 | 8 52 | 7 53 | 654 | 5 55 | 4 56 | 3 57 | 258 | 691 | 090 | | 1 | |
| | Cosine. | 9435122 3 | 9433192 3 | 9432227 3 | 9431260 3 | 94293243 | 9428355 3 | 94273863 | 9426415 3 | 9425444 2 | 9424471 2 | 9423498 2 | 9422525 2 | 9421550 2 | 9420575 2 | 9419598 2 | 9418621 2 | 9417644 2 | 94166652 | | Sine. | Deg. 70 |
| | Tang. Cotang. Cosine. | 2.847583 | 2.842292 | 2.839653 | 2.837019 | 2.831763 | 2.829142 | 2-826525 | 2.823912 | 2.821304 | 2.818700 | 2.816100 | 2.813504 | 2.810913 | 928808-2 | 2-805743 | 2.803164 | 2-800590 | 2.798019 | | Tang. | |
| | Tang. | 351175 | 351828 | -352155 | -352482 | 353136 | -353464 | -353791 | .354118 | 354446 | .354773 | .355101 | .355428 | 922228 | .356084 | 356411 | .356739 | -357067 | -357395 | | Cotang. | |
| 19 Deg. | Sine. | 3313379 | 3318867 | -3321611 | -3324355 | 3329841 | -3332584 | 3335326 | -3338069 | 3340810 | -3343552 | -3346293 | -3349034 | -3351775 | 3354516 | -3357256 | -3359996 | 3362735 | 3365475 | | Cosine. Cotang. | |
| 19 | _ | 0 21 | 23 23 | 7 24 | 625 | 4 27 | 3 28 | 2 29 | 1 30 | 031 | 932 | 833 | 734 | 6 35 | 536 | 437 | 338 | 239 | 1 10 | 0 | 11 | |
| | Cosine, | 3255682 344327 2-904210 -9455186 60 21 -3313379 -351175 2-847583 -9435122 39 41 -3368214 -357723 2-795453 -9415686 19 | .3261182.344978 2.898731 49453290 5823.3318867 351828 2.842292 37193 37143 3373691 358380 2.790333 9413724 | $\cdot 3263932 \cdot 345304 \cdot 2\cdot 895998 \cdot 9452341 \cdot 57 \cdot 24 \cdot 3321611 \cdot 352165 \cdot 2\cdot 839653 \cdot 943227 \cdot 36 \cdot 44 \cdot 3376429 \cdot 358708 \cdot 2\cdot 87780 \cdot 9412743 \cdot 376429 \cdot 367780 \cdot 36$ | 3266681 345629 2.893270 -9451391 5625 -3324355 -352482 2.837019 -9431260 3545 -3379167 -359036 2.785230 -9411760 | 3272179 346281 2:880546 9450441 35726 3321098 352569 2:834563 9450283 44 40 358462 359355 2:78044 49409793 | $-3274928 \cdot 346606 \cdot 2885113 \cdot 9448537 \cdot 5328 \cdot 3332584 \cdot 353464 \cdot 2829142 \cdot 9428355 \cdot 3248 \cdot 3387379 \cdot 360022 \cdot 2777606 \cdot 940808 \cdot 387379 \cdot 38737$ | $3277676 \cdot 346932 \cdot 282403 \cdot 9447584 \cdot 52 \cdot 29 \cdot 3335326 \cdot 353791 \cdot 2 \cdot 826525 \cdot 9427386 \cdot 31 \cdot 49 \cdot 3390116 \cdot 360350 \cdot 2775073 \cdot 9407822 \cdot 277676 \cdot 346932 \cdot 277677 \cdot 246778 | $\cdot 3280424 \cdot 347258 \\ 2\cdot 879697 \cdot 9446630 \\ 51 \\ 30 \cdot 3038069 \cdot 354118 \\ 2\cdot 823912 \cdot 9426415 \\ 30 \\ 50 \cdot 3392852 \cdot 360679 \\ 2\cdot 772544 \\ 9406835 \\ 30 \\ 50 \cdot 3992852 \\ 36079 \\ 30 \cdot 772544 \\ 9406835 \\ 30 \cdot 30 \cdot 30 \cdot 30 \cdot 30 \\ 30 \cdot 30 \cdot 30$ | $.3283172 \cdot 347584 \cdot 2.876997 \cdot 9445675 \cdot 50 \cdot 31 \cdot 3340810 \cdot 354446 \cdot 2.821304 \cdot 9425444 \cdot 29 \cdot 51 \cdot 3395589 \cdot 361008 \cdot 2.770019 \cdot 9405848 \cdot 3283172 \cdot 347584 \cdot 29 \cdot 21 \cdot 3395589 \cdot 361008 \cdot 2.770019 \cdot 9405848 \cdot 3283172 \cdot 347584 \cdot 29 \cdot 21 \cdot 3395589 \cdot 361008 \cdot 2.770019 \cdot 9405848 \cdot 361008 \cdot 2770019 \cdot 9405848 \cdot 381008 \cdot 2770019 \cdot 381008 \cdot 2770019 \cdot 381008 \cdot 2770019 \cdot 381008 \cdot 2770019 \cdot 381008 \cdot 3810008 \cdot 381008 \cdot 381008 \cdot 381008 \cdot 381008 \cdot 381008 \cdot 381008 \cdot 3810008 \cdot 3810008 \cdot 3810008 \cdot 38100008 \cdot 38100008 \cdot 3810000000000000$ | $\cdot 3285919 \cdot 347910 \cdot 2 \cdot 874300 \cdot 9444720 \cdot 49 \cdot 32 \cdot 3343552 \cdot 354773 \cdot 2 \cdot 818700 \cdot 9424471 \cdot 2852 \cdot 3398325 \cdot 361337 \cdot 2 \cdot 767499 \cdot 9404860 \cdot 3285919 \cdot 347910 \cdot$ | $32888666 \cdot 348236 \cdot 2671608 \cdot 9443764 \cdot 4833 \cdot 3346293 \cdot 355101 \cdot 2816100 \cdot 9423498 \cdot 2753 \cdot 3401060 \cdot 361666 \cdot 2764982 \cdot 9403871 \cdot 2816100 \cdot 381668 \cdot 381688 \cdot 381688 \cdot 38$ | $\cdot 3291413 \cdot 348563 \cdot 2 \cdot 868921 \cdot 9442807 \cdot 47734 \cdot 3349034 \cdot 355428 \cdot 2 \cdot 813504 \cdot 9422525 \cdot 2654 \cdot 3403796 \cdot 361994 \cdot 2 \cdot 762469 \cdot 940288 \cdot 3 \cdot 3 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot 10 \cdot$ | $\cdot 3294160 \cdot 348889 \cdot 286238 \cdot 9441849 \cdot 46 \cdot 35 \cdot 3351775 \cdot 335756 \cdot 2810913 \cdot 9421550 \cdot 25 \cdot 55 \cdot 3406531 \cdot 362324 \cdot 28759960 \cdot 9401891 \cdot 38889 \cdot 288889 \cdot 28889 \cdot 288889 \cdot 28889 | $\cdot 3296906 \cdot 349215 \cdot 2 \cdot 863560 \cdot 9940890 \cdot 45 \cdot 36 \cdot 3354516 \cdot 356084 \cdot 2 \cdot 808326 \cdot 9420575 \cdot 2456 \cdot 3409265 \cdot 362653 \cdot 2 \cdot 757456 \cdot 9400899 \cdot 3296906 \cdot 349215 \cdot 2 \cdot $ | $\cdot 3299653 \cdot 349542 \cdot 2 \cdot 860886 \cdot 9439931 \cdot 44 \cdot 37 \cdot 3357256 \cdot 356411 \cdot 2 \cdot 805743 \cdot 9419598 \cdot 23 \cdot 57 \cdot 3412000 \cdot 362982 \cdot 2 \cdot 754955 \cdot 9399907 \cdot 2 \cdot 754955 \cdot 754956 \cdot 75496 \cdot 754966 \cdot 75496 \cdot 7$ | $?7 : 330 : 2398 : 349868 : 2 \cdot 85 : 3216 : 9438971 : 4338 : 3359996 \cdot 356739 : 2 \cdot 803164 \cdot 9418621 : 2258 : 3414734 \cdot 363311 : 2 \cdot 752458 \cdot 9338914 : 3 \cdot 3630 : 3688 $ | $\cdot 3305144 \cdot 350195 \cdot 2855551 \cdot 9438010 \cdot 42399 \cdot 3362735 \cdot 357067 \cdot 2800590 \cdot 9417644 \cdot 2159 \cdot 3417468 \cdot 363640 \cdot 2749966 \cdot 9397921 \cdot 386767 \cdot 286767 \cdot 286767 \cdot 286767 \cdot 286777 \cdot 28677 \cdot 286777 \cdot 28677 \cdot 286777 \cdot 2867$ | $19 \cdot 3307889 \cdot 350521 \cdot 2 \cdot 52891 \cdot 9437048 \cdot 41 \cdot 10 \cdot 3365475 \cdot 357395 \cdot 2 \cdot 798019 \cdot 9416665 \cdot 20 \cdot 60 \cdot 3420201 \cdot 363970 \cdot 2 \cdot 47477 \cdot 9396926 \cdot 3007889 \cdot 300789 \cdot 300$ | 20 3310634 350848 2850234 9436085 40 | Sine. | Deg. 70. |
| | Tang. Cotang. | 2.904210 | 2.898731 | 2.895998 | 2-893270 | 2.887827 | 2.885113 | 2.882403 | 2.879697 | 2.876997 | 2.874300 | 2.871608 | 2.868921 | 2.866238 | 2-863560 | 2.860886 | 2.853216 | 2.855551 | 2.852891 | 2.850234 | Tang. | |
| | Tang. | -344327 | -344978 | -345304 | 345629 | 345955 | .346606 | 346932 | -347258 | -347584 | .347910 | .348236 | -348563 | .348889 | 349215 | 349542 | .349868 | 350195 | .350521 | -350848 | Cotang. | |
| 19 Deg. | Sine. | 3255682 | 3261182 | 3263932 | 3266681 | 3269430 | 3274928 | 3277676 | 3280424 | 3283172 | 3285919 | 3288666 | 3291413 | 3294160 | 3296906 | 3299653 | 3302398 | 3305144 | 3307889 | 3310634 | Cosine. | |
| 19 1 | - | 0. | 4 64 | 33 | | 9 | 1 | 00 | 6 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 18 | 20 | - | |

NATURAL SINES AND TANGENTS TO A RADIUS I.

| 20 Deg. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. Sine. Sine. Tang. Cotang. Cosine. 4-9374846 3941-3532027 377536 2-648753 9355440 14-9372820 3644-3534748 377868 2-644043 9355440 14-9372820 3644-3540190 37853 2-644774 93553412 19-9372820 3644-3540190 37853 2-644774 9353412 13-93657740 344-3540190 37853 2-644774 9353412 13-9365772 3050 37530 37953 12-634827 9349289 11-936572 3050 3553789 380197 2-63213 9347129 11-936572 3050 3553789 380197 2-63219 3947223 11-936572 3050 3553926 381362 2-618741 9343045 11-9365703 2951 3-3564662 381529 2-614176 9343184 1955 3554362 381529 2-614176 9343088 1962 381529 2-614176 9343088 1962 381529 2-614176 9339968 1935647 2258 3578244 382529 2-614176 9339968 1935647 2258 3578248 383196 2-605089 9335894 | | - | - | ~ | _ | ** | | _ | ~ | - | _ | _ | _ | ~ | _ | - | | _ | ~ | ~2 | - | - | - | 7 |
|--|------|---------|-----------|----------|-----------|----------|----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|----------|---------|
| 20 Deg. Sine. Tang. Cotang. Cosine. Cosine. Sine. Tang. Cotang. Cosine. Cosi | | - | 125 | 18 | 2 | 116 | 15 | 2 | 22 | 123 | Ξ | = | 5 | 8 | - | - | 7 | _ | - | - | | _ | _ | - |
| 20 Deg. Sine. Cotang. | Cosine. | 935546 | 9354440 | 9353415 | 9352385 | 9351355 | 9350321 | 9349285 | .9348257 | 9347223 | 9346188 | 9345154 | 9344115 | 9343085 | 9342046 | -9341007 | -9339968 | -9338928 | ·9337888 | 9336846 | -9335804 | | Sine. |
| Sine | | Cotang. | 2-648753 | 2-646423 | 2.644096 | 2-641774 | 2-639454 | 2-637139 | 2-634827 | 2-632518 | 2.630213 | 2.627912 | 2-625614 | 2-623319 | 820129-2 | 2.618741 | 2-616457 | 2-614176 | 2-611899 | 2-609625 | 2-607355 | 2-605089 | | Tang. |
| 20 Deg. Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. Sine. S | | Tang. | -377536 | -377868 | 378201 | -378533 | -378866 | 861628 | .379531 | -379864 | 380197 | -380530 | -380863 | -381196 | -381529 | 381862 | 382196 | 382529 | 382863 | 883196 | 383530 | -383864 | - | Cotang. |
| 20 Deg. Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. Sine. Sine. Sine. Cotang. Cosine. Sine. S | Deg. | Sine. | -3532027 | 3534748 | -3537469 | -3540190 | 3542910 | -3545630 | 3548350 | 3551070 | -3553789 | 3556508 | -3559226 | 3561944 | 3564662 | 3567380 | 3570097 | -3572814 | 3575531 | 8578248 | 3580964 | 3583679 | | Cosine. |
| 20 Deg. Sine. Tang. Cotang. Cosine. Sine. Tang. Sine. Sine. Tang. Cotang. Cosine. Sine. Tang. Sine. | 20 | - | 941 | 8 42 | 743 | 644 | 5.45 | 446 | 347 | 248 | 149 | 020 | 951 | 8 52 | 753 | 654 | 555 | 4 56 | 3,57 | 258 | 159 | 090 | | 1 |
| Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cotang. Sine. Tang. Cotang. Cotang. Sine. Tang. Cotang. Cotang. Cotang. Cotang. Sine. Tang. Cotang. Cotang. Sine. Tang. Cotang. Sine. Sine. Tang. Cotang. Sine. Si | | Cosine. | 9375858 3 | 93748463 | 9373833 3 | 93728203 | 9371806 | 9370790 3 | 9369774 3 | 9368758 3 | 9367740 3 | 9366722 3 | 9365703 2 | 9364683 2 | 9363662 2 | 9362641 2 | 9361618 2 | 9360595 2 | 9359571 2 | 9358547 2 | 9357521 2 | 9356495 2 | 1 | Sine. |
| 20 Deg. Sine. Tang. Cotang. Cosine. Sine. Tang. 1:3422935 3422940 370903 1:3422935 364299 2.747477 9396926 6021 3477540 371234 2:3422668 364629 2.742512 9392935 5623 348294 371565 3:44260 36652 2.742512 9392935 5723-3488447 372227 5723628 2737562 9392943 5723628 3488447 372227 5723639 366277 273068 9399943 5427 3493898 372227 372329 366277 272307 93889943 5529 349389 372321 366277 372309 372309 377309 | | Cotang. | 2.696118 | 2-693714 | 2.691314 | 2.688919 | 2.686526 | 2.684138 | 2.681753 | 2.679372 | 2.676995 | 2-674621 | 2.672251 | 2-669885 | 2.667522 | 2-665163 | 808299-2 | 2-660456 | 2.658108 | 2-655764 | 2-653423 | 2-651086 | 1 | Tang. |
| Sine. Tang. Cotang. Cosine. Sine. Sine. Sine. Cosine. | | | -370903 | -371234 | -371565 | -371896 | 372227 | -372559 | .372890 | .373221 | 373553 | -373884 | .374216 | -374547 | 374879 | 875211 | 375543 | 375875 | 376207 | 376539 | 376871 | -377203 | | Cotang. |
| Sine. Tang. Cotang. Cosine. | Deg. | Sine, | 3477540 | 3480267 | -3482994 | 3485720 | 3488447 | 3491173 | 3493898 | -3496624 | -3499349 | 3502074 | -3504798 | -3507523 | 3510246 | 3512970 | 3515693 | 3518416 | 3521139 | 3523862 | 3526584 | 3529306 | | Cosine. |
| Sine. Tang. Cotang. Cosine. Sine. 1383970 2747477 9396926 60 1-3422935 364299 2744992 -3395931 59 2-3422668 364299 2744992 -3393938 57 3428400 364529 27742512 93994935 58 3-342865 036429 27742512 9399493 58 54 343813 365288 2773262 9399494 55 6-3439329 365277 2730167 9389943 53 8 344261 386537 272526 9387994 49 10 345252 367928 27725307 9386938 50 11 3452982 367928 2771710 9386938 50 11 3452982 367928 2771710 9389894 49 12 3452982 367928 2771710 9389993 54 13 3452982 367928 2771710 9389991 345 15 346628 389586 27705769 9381913 45 15 346628 389580 27705769 9381913 45 15 3466390 389520 27705192 9381913 45 15 3466390 389520 27705769 9379889 43 19 3472885 370572 2698525 937889 42 70 3474812 370572 2698525 937889 42 70 3474812 770872 2698525 937889 42 70 70872 2698525 937889 42 70 70 70 70 70 70 70 70 70 70 70 70 70 | 20 | - | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 58 | 30 | 31 | 35 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | | - |
| Sine. Tang. Cotang. Cosine. 1 - Sine. Tang. Cotang. Cosine. 1 - 3422935 - 364299 2-74492 - 393593 2 - 342566 - 364629 2-742512 - 9394935 3 - 3423866 - 36568 2-742512 - 9394935 5 - 3433133 - 365288 2-73562 - 9392944 5 - 3433657 - 365948 2-73569 - 3939944 7 - 3439329 - 366277 2-73167 - 9389945 8 - 344266 - 366677 2-72710 - 9388945 9 - 344766 - 366677 2-72710 - 9388941 10 - 3452982 - 367598 2-713048 - 9382921 11 - 3452982 - 367598 2-713048 - 9382921 12 - 345391 - 388258 2-715482 - 9389998 13 - 345390 - 389250 2-71648 - 9381918 14 - 346638 - 369592 2-71648 - 9381918 15 - 346111 - 368919 2-710618 - 9379896 17 - 346638 - 369580 2-705769 - 9379896 18 - 3469357 - 369911 2-703351 - 937888 20 - 3474812 - 370572 2-698525 - 9376888 20 - 3474812 - 370572 2-698525 - 9376888 | | | 9 9 | 159 | 99 | 57 | 99 | 55 | 154 | 153 | 52 | 121 | 150 | 149 | 48 | 47 | 46 | 145 | 14 | 43 | 42 | 41 | 740 | * |
| Sine. Tang. Cotang. Sine. 1989-6 | | | -9396926 | -9395931 | -9394933 | -9393938 | -939294(| -939194% | -9390943 | -9389948 | 9388942 | ·938794(| -9386938 | -9385934 | .9384930 | .9383925 | 9382920 | 9381918 | -9380906 | -9379896 | 9378889 | 9377880 | 2000/06. | Sine, |
| Sine. Tang. Sine. Tang. 13422935 364229 2 3425668 364629 3 3422440 364529 3 3422440 364529 4 3431133 365288 5 343886 365618 7 3439329 366277 8 344060 366077 9 3447521 367268 11 345252 367268 12 345292 3672928 13 345292 3672928 14 345292 369250 15 3469300 369250 16 3453900 369250 17 3466628 369550 18 3459357 369911 19 3474812 370572 Cosine. Cotang. | | Cotang. | 2-747477 | 2.744992 | 2-742512 | 2-740035 | 2-737562 | 2-735093 | 2-732628 | 2-730167 | 2 727710 | 2-725256 | 2-722807 | 2-720362 | 2-717920 | 2-715482 | 2-713048 | 8-710618 | 2.708192 | 2-705769 | 2-703351 | 2-700936 | 020000.0 | Tang. |
| Sine. Sine. O 3429201 1 3422935 2 3425668 3 3428400 3 4383865 5 3433865 6 3436597 7 3439329 8 344779 10 3457260 10 3457261 11 3450252 12 345840 12 345840 14 345841 15 3468390 17 3466628 18 3469357 19 3472085 19 3474812 19 3474812 10 3474812 | | Tang. | .363970 | -364299 | 364629 | 364958 | 365288 | 365618 | 365948 | 366277 | -366607 | -366937 | 367268 | -367598 | 367928 | -368258 | 368589 | 368919 | 369250 | ·36958C. | 369911 | -370242 | zienie. | Cotang. |
| 08 1018846860000188846811 | Deg. | Sine. | 3420201 | 3422935 | 3425668 | 3428400 | 3431133 | 3433865 | 3436597 | 3439329 | 3442060 | 3444791 | 3447521 | 3450252 | 3452982 | 3455712 | 3458441 | 3461171 | 3463900 | 3466628 | 3469357 | 3472085 | 2101110 | Cosine. |
| | 08 | 1 | 0 | 1 | 64 | 9 | 4 | 10 | 9 | - | 00 | 6 | 10 | 11 | 12 | 13 | 14 | 15 | 91 | 17 | 18 | 19 | 1 | |

| | 2 - | 21 Deg. | | | | | El Deg. | eg. | | | - | 2 | 21 Deg. | | - | | -1 |
|----|-----|---------------------------------------|---------|----------|----------|------|---------|--------|-----------------|----------|--|--------|------------|-----------------|----------|----------|-----|
| 1 | - | Sine. | Tang. | Cotang. | Cosine. | , | - | Sine. | Tang. | Cotang. | Cosine | , | Sine. | 'Fang. | Cotang. | Cosine. | |
| 15 | 0 | .3583679 | -383864 | 2-605089 | -9335804 | 602 | 11 .3 | 540641 | 390889 | 2-558268 | 0 3583679 383864 2 605089 9335804 6021 3640641 390889 2 558268 9313739 3941 3694765 397611 2 515018 9292401 | 39 4 | 369476 | 5 -397611 | 2 515018 | -9292401 | 19 |
| | - | -3586395 | 384197 | 2.602825 | 9334761 | 592 | 2 3 | 643351 | 391224 | 2.556075 | $-3586395 \\ -384197 \\ 2 \cdot 602825 \\ -9334761 \\ 5923 \\ -3643351 \\ -391224 \\ 2 \cdot 556075 \\ -9312679 \\ $ | 38 45 | 369746 | 8 -397948 | 2.512889 | -9291326 | 18 |
| | 65 | -3589110 -384531 2-600565 | 384531 | 2-600565 | 9333718 | 582 | 3 3 | 646059 | 391560 | 2.553885 | 9333718 5823 3646059 391560 2 553885 9311619 3743 3700170 398285 2 510762 9290250 | 374 | 3 -3700170 | 398286 | 2-510762 | 9290250 | 17 |
| | 3 | -3591825 | 384865 | 2-598309 | -9332673 | 572 | 4 3 | 648768 | 391895 | 2-551699 | 3591825 384865 2.598309 9332673 5724 3648768 391895 2.551699 9310558 3644 3702872 398622 2.508639 9289173 | 364 | 1-370287 | 2 -398622 | 2.508639 | 9289173 | 16 |
| | 4 | -3594540 | 385199 | 2.596056 | -9331628 | 562 | 5 3 | 651476 | 392231 | 2.549516 | $\cdot 3594540 \cdot 385199 \cdot 2 \cdot 596056 \cdot 9331628 \cdot 5625 \cdot 3651476 \cdot 392231 \cdot 2 \cdot 549516 \cdot 9309496 \cdot 3545 \cdot 3705574 \cdot 398959 \cdot 2 \cdot 506519 \cdot 9288096 \cdot 3646 $ | 354 | 5 3705574 | 1-398959 | 2.506519 | 9538096 | 91 |
| | 10 | 3597254 | -385533 | 2-593806 | -9330582 | 552 | 6 .3 | 654184 | 392567 | 2.547335 | $\cdot 3597254 \cdot 385523 \cdot 2 \cdot 593806 \cdot 9930582 \cdot 55 \cdot 26 \cdot 3654184 \cdot 392567 \cdot 2 \cdot 547335 \cdot 9308434 \cdot 3446 \cdot 3708276 \cdot 399296 \cdot 2 \cdot 504403 \cdot 9287017 \cdot 387876 \cdot 388676 \cdot $ | 34 40 | 3 -370827 | 3999296 | 2.504403 | -9287017 | 14 |
| | 9 | -3599968 | 385867 | 2-591560 | -9329535 | 542 | 17 .3 | 168999 | 392902 | 2-545159 | $\cdot 3599968 \cdot 385867 \cdot 2 \cdot 591560 \cdot 9329535 \cdot 5427 \cdot 3656891 \cdot 392902 \cdot 2 \cdot 545159 \cdot 9307370 \cdot 33177 \cdot 3710977 \cdot 399634 \cdot 2 \cdot 502289 \cdot 9285938 \cdot 388867 \cdot 38$ | 33 1 | 7-3710977 | 7 -399634 | 2.502289 | .9285938 | 13 |
| | 1 | | 386202 | 2.589317 | .9328488 | 532 | 8 .3 | 626269 | 393238 | 2.542985 | 3602682 386202 $2.589317 9328488 5328 3659599 393238 2.542985 9306306 3288 8733678 399971 2.500178 9284858$ | 32 18 | 3 3713678 | 3 -399971 | 2.500178 | 9284858 | 12 |
| | 00 | | -386536 | 2.587078 | -9327439 | 522 | 9 3 | 908299 | 393574 | 2.540815 | $\cdot 3865395 \cdot 386536 \cdot 2587078 \cdot 9327439 \cdot 5229 \cdot 3662306 \cdot 393574 \cdot 2540815 \cdot 9305241 \cdot 31149 \cdot 3716379 \cdot 400308 \cdot 2498070 \cdot 9283778 \cdot 31169 \cdot 3116379 \cdot 31$ | 31 49 | 3716379 | 9.400308 | 2.498070 | -9283778 | 11 |
| | 6 | 3608108 | .386870 | 2 584842 | -9326390 | 513 | 0 3 | 665012 | 333310 | 2-538647 | $3608108 \cdot 386870 \cdot 2584842 \cdot 9326390 \cdot 5130 \cdot 3665012 \cdot 393910 \cdot 2538647 \cdot 9304176 \cdot 3050 \cdot 3719079 \cdot 400646 \cdot 2495966 \cdot 9282696 \cdot 3608108 \cdot 360$ | 3050 | 3719078 | 9-400646 | 2.495966 | -9282696 | 10 |
| K | 10 | .3610821 | 387205 | 2.582609 | -9325340 | 503 | 11.3 | 667719 | 394246 | 2.536483 | $\times 10^{-3610821 \cdot 387205} \times 582609 \cdot 9325340 \cdot 50^{ 31 \cdot 3667719 \cdot 394246} \times 536483 \cdot 9303109 \cdot 2951 \cdot 3721780 \cdot 400984 \cdot 2493864 \cdot 9281614$ | 295 | 3721780 | 400084 | 2-493864 | -9281614 | 6 |
| | 11 | -3613534 | .387539 | 2.580380 | 9324290 | 493 | 2 .3 | 670425 | 391582 | 2.534323 | $11 \cdot 3613534 \cdot 387539 \cdot 2.580380 \cdot 9324290 \cdot 49132 \cdot 3670426 \cdot 391528 \cdot 2.534323 \cdot 9302042 \cdot 28152 \cdot 3724479 \cdot 401321 \cdot 2.491766 \cdot 928053 \cdot 9302042 \cdot 2.61320 \cdot 2.4479 \cdot 401321 \cdot 2.491766 \cdot 928053 \cdot 9302042 \cdot 9302040 \cdot 9302042 \cdot 930204$ | 28 5 | 3724478 | 0.401321 | 2.491766 | -9280531 | 00 |
| | 12 | 3616246 | -387874 | 2-578153 | 9323238 | 483 | 13 -3 | 673130 | 816168 | 2.532165 | 12.3616246.387874 $2.578153.9323238$ $48 33.3673130.394918$ $12.532165.9300974$ $12.753.3727179$ 12.659 12.407947 | 275 | 31.3727179 | 9.401659 | 2.489670 | 9279447 | 7 |
| | 13 | -3618958 | 388209 | 2.575931 | 9322186 | 473 | 14 3 | 675836 | 395255 | 2.530011 | $13_73618968 \cdot 388209 \cdot 2575931 \cdot 9322186 \cdot 4734 \cdot 3675836 \cdot 395255 \cdot 2.530011 \cdot 9299905 \cdot 2654 \cdot 3729878 \cdot 401997 \cdot 2487578 \cdot 9278363 \cdot 3229878 \cdot 2487578 \cdot 248778 \cdot 2487578 \cdot 248778 \cdot 248778 \cdot 248778 \cdot 248778 \cdot 248778 \cdot 248778 \cdot 24877$ | 265 | 1-3729875 | 3 -401997 | 2.487578 | 9278363 | 9 |
| | 14 | .3621669 | 388543 | 2-573711 | 9321133 | 463 | 5 3 | 678541 | 395591 | 2.527859 | 14.3621669.3885432.573711.93211334635.3678541.3955912.527859.92988352656.3732577.4023352485488.9277277 | 25 58 | 5 -3732577 | 7 -402335 | 2-485488 | 19277277 | 3 |
| | 15 | -3621380 | 388878 | 2.571495 | 9320079 | 453 | 16 -3 | 681246 | 335928 | 2-525711 | $15.3624380 \cdot 388878 \cdot 2571495 \cdot 9320079 \cdot 4536 \cdot 3681246 \cdot 395928 \cdot 2525711 \cdot 9297765 \cdot 2456 \cdot 3735275 \cdot 402673 \cdot 2483402 \cdot 927619 \cdot 328878 \cdot 2483402 \cdot 2483403 \cdot 24$ | 245 | 373527 | 5 -402673 | 2.483402 | 19276191 | 4 |
| | 161 | 1-3627091 | 389213 | 2.569283 | 9319024 | 443 | 17 .3 | 683950 | 396264 | 2.523566 | $16 \cdot3627091 \cdot389213 2\cdot569283 \cdot9319024 44 37 \cdot3683950 \cdot396264 2\cdot523566 \cdot9296694 23 57 \cdot3737973 \cdot403011 2\cdot481319 \cdot9275104 37 19 19 19 19 19 19 19 19 19 19 19 19 19 $ | 235 | 7-3737973 | 3 403011 | 2-481319 | -9275104 | 00 |
| | 17 | -3623802 | 389548 | 2-567073 | -9317969 | 433 | 8 3 | 199989 | 396601 | 2.521424 | 17.3623802.383548.2567073.9317969.4338.3686654.396601.2521424.9295622.2258.3740671.403349.2479238.9274016 | 22 58 | 3-374067 | 403349 | 2.479238 | .9274016 | 63 |
| | 18 | 3632512 | 389883 | 2.564867 | 9316912 | 423 | 8.6 | 689358 | 396937 | 2.519286 | $18^{\circ}3632512^{\circ}389883^{\circ}2\cdot564867^{\circ}9316912^{\circ}4239^{\circ}3689358^{\circ}396937^{\circ}2\cdot519286^{\circ}9294549^{\circ}21^{\circ}59^{\circ}3743369^{\circ}403687^{\circ}2477161^{\circ}9272928^{\circ}36977^{\circ}3697^{$ | 21 5 | 9-3743369 | 9-403687 | 2-477161 | 9272928 | - |
| | 19 | .3635222 | .390218 | 2.562664 | -9315855 | 414 | 0 3 | 692061 | 397274 | 2-517150 | $9 \cdot 3635222 \cdot 390218 \cdot 2 \cdot 562564 \cdot 9315855 \cdot 41 \cdot 40 \cdot 3692061 \cdot 397274 \cdot 2 \cdot 517150 \cdot 9293475 \cdot 20 \cdot 60 \cdot 3745066 \cdot 404026 \cdot 2 \cdot 475086 \cdot 9271839$ | 2060 | 3746066 | 3 404026 | 2.475086 | 9271839 | 0 |
| | 0% | 20 3637932 390554 2.560464 9314797 40 | -390554 | 2.560464 | 9314797 | 40 | | | | | | | | | | | |
| - | 1- | Cosine. | Cotang. | Tang. | Sine. | - | 1 | osine. | Cosine. Cotang. | Tang. | Sine. | 1 | | Cosine. Cotang. | Tang. | Sine. | 1- |
| | 1 | - | | | Dog 68 | R.A. | 1 | | 1 | | Dec. 68. | 68. | | 1 | | Dec. 68. | l œ |
| | | | | | - 100 | .00 | | | | | - NOW | 111,20 | | | | 1000 | |

NATIURA SINES AND TANGENTS TO A KADIUS 1.

| 22 Deg. Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cotang. Sine. Tang. Cotang. Cotang. Sine. Tang. Cotang. Cotang. Sine. Tang. Cotang. Cotang. Cotang. Sine. Tang. Cotang. Cotang. Sine. Tang. Cotang. Sine. Tang. Cotang. Sine. Tang. Sine. | 10 | 47 | 19 | 18 | 17 | 91 | 15 | 14 | 13 | 12 | 11 | 10 | 6 | 8 | 7 | 9 | 5 | 4 | 3 | 65 | - | 0 | | 1 | 1 |
|--|------|---------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|---------|----------|
| 22 Deg. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. 163 - 404026 2-475086 9271839 6021 3802634 411149 2-432204 92448782 3941 4164026 2-475086 9271839 6021 3802634 411149 2-432193 9247676 3842 4204364 2-473015 9270748 592 3808014 411803 2-428186 9244351 3544 410801 2-464759 9265666 5724 38180704 4411803 2-428186 9244351 3344 410809 2-464759 9265880 5526 3816082 412510 2-422181 9244321 3347 406571 2-466479 9265880 5526 3816082 412510 2-422181 9244321 3347 406571 2-464759 9265880 5526 3816082 412851 2-422181 9244321 3347 406573 2-46655 9265996 5229 3824147 413872 2-416201 9233795 305 40657 2-46655 9265996 5229 3824147 413213 2-418218 92237682 295 4140774 2-46655 9265996 5229 3824147 413213 2-418218 9233795 412218 9233795 205 418218 2-416201 9233795 205 418218 2-416201 9233795 412218 9233795 205 418218 2-416201 9233795 412218 9233795 205 418218 2-416201 9233795 412218 9233795 205 418218 9241023 2-48435 925 418218 9241023 418218 9241023 418218 9241023 2-48435 925 418218 9241023 418218 9241023 418218 9241023 418218 9241023 418218 9241023 418218 9241023 418218 9241023 418218 9241088 418218 9241088 418218 9241088 418218 9241088 418218 925093 4140 3853693 417625 2-394488 9221624 2060 9244217 9243888 4060000000000000000000000000000000000 | | Cosine. | 9226503 | 9225381 | 9224258 | 9223134 | 9222010 | 9220884 | 9219758 | 9218632 | 9217504 | 9216375 | 9215246 | 9214116 | 9862126 | 9211854 | 9210722 | 9209589 | 9208455 | 9207320 | 9206185 | 9205049 | | Sine. | Dec 67 |
| 22 Deg. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. 163 - 404026 2-475086 9271839 6021 3802634 411149 2-432204 92448782 3941 4164026 2-475086 9271839 6021 3802634 411149 2-432193 9247676 3842 4204364 2-473015 9270748 592 3808014 411803 2-428186 9244351 3544 410801 2-464759 9265666 5724 38180704 4411803 2-428186 9244351 3344 410809 2-464759 9265880 5526 3816082 412510 2-422181 9244321 3347 406571 2-466479 9265880 5526 3816082 412510 2-422181 9244321 3347 406571 2-464759 9265880 5526 3816082 412851 2-422181 9244321 3347 406573 2-46655 9265996 5229 3824147 413872 2-416201 9233795 305 40657 2-46655 9265996 5229 3824147 413213 2-418218 92237682 295 4140774 2-46655 9265996 5229 3824147 413213 2-418218 9233795 412218 9233795 205 418218 2-416201 9233795 205 418218 2-416201 9233795 412218 9233795 205 418218 2-416201 9233795 412218 9233795 205 418218 2-416201 9233795 412218 9233795 205 418218 9241023 2-48435 925 418218 9241023 418218 9241023 418218 9241023 2-48435 925 418218 9241023 418218 9241023 418218 9241023 418218 9241023 418218 9241023 418218 9241023 418218 9241023 418218 9241088 418218 9241088 418218 9241088 418218 9241088 418218 925093 4140 3853693 417625 2-394488 9221624 2060 9244217 9243888 4060000000000000000000000000000000000 | | | 2-392531 | 2-390576 | 2.388625 | 2.386675 | 2.384729 | 2.382785 | 2.380844 | 2.378906 | 2-376970 | 2.375037 | 2-373106 | 2.371179 | 2.369254 | 2.367331 | 2.365411 | 2.363494 | 2.361580 | 2-359668 | 2-357759 | 2-355852 | | Tang. | |
| 22 Deg. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. 163 - 404026 2-475086 9271839 6021 3802634 411149 2-432204 92448782 3941 4164026 2-475086 9271839 6021 3802634 411149 2-432193 9247676 3842 4204364 2-473015 9270748 592 3808014 411803 2-428186 9244351 3544 410801 2-464759 9265666 5724 38180704 4411803 2-428186 9244351 3344 410809 2-464759 9265880 5526 3816082 412510 2-422181 9244321 3347 406571 2-466479 9265880 5526 3816082 412510 2-422181 9244321 3347 406571 2-464759 9265880 5526 3816082 412851 2-422181 9244321 3347 406573 2-46655 9265996 5229 3824147 413872 2-416201 9233795 305 40657 2-46655 9265996 5229 3824147 413213 2-418218 92237682 295 4140774 2-46655 9265996 5229 3824147 413213 2-418218 9233795 412218 9233795 205 418218 2-416201 9233795 205 418218 2-416201 9233795 412218 9233795 205 418218 2-416201 9233795 412218 9233795 205 418218 2-416201 9233795 412218 9233795 205 418218 9241023 2-48435 925 418218 9241023 418218 9241023 418218 9241023 2-48435 925 418218 9241023 418218 9241023 418218 9241023 418218 9241023 418218 9241023 418218 9241023 418218 9241023 418218 9241088 418218 9241088 418218 9241088 418218 9241088 418218 925093 4140 3853693 417625 2-394488 9221624 2060 9244217 9243888 4060000000000000000000000000000000000 | | Tang. | 417967 | 418309 | 418650 | 418992 | 419334 | 419676 | 420019 | 420361 | 420703 | 421046 | 421388 | 421731 | 422073 | 422416 | 422759 | -423102 | 423445 | 423788 | 424131 | 424474 | | Cotang. | |
| 22 Deg. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. 163 - 404026 2-475086 9271839 6021 3802634 411149 2-432204 92448782 3941 4164026 2-475086 9271839 6021 3802634 411149 2-432193 9247676 3842 4204364 2-473015 9270748 592 3808014 411803 2-428186 9244351 3544 410801 2-464759 9265666 5724 38180704 4411803 2-428186 9244351 3344 410809 2-464759 9265880 5526 3816082 412510 2-422181 9244321 3347 406571 2-466479 9265880 5526 3816082 412510 2-422181 9244321 3347 406571 2-464759 9265880 5526 3816082 412851 2-422181 9244321 3347 406573 2-46655 9265996 5229 3824147 413872 2-416201 9233795 305 40657 2-46655 9265996 5229 3824147 413213 2-418218 92237682 295 4140774 2-46655 9265996 5229 3824147 413213 2-418218 9233795 412218 9233795 205 418218 2-416201 9233795 205 418218 2-416201 9233795 412218 9233795 205 418218 2-416201 9233795 412218 9233795 205 418218 2-416201 9233795 412218 9233795 205 418218 9241023 2-48435 925 418218 9241023 418218 9241023 418218 9241023 2-48435 925 418218 9241023 418218 9241023 418218 9241023 418218 9241023 418218 9241023 418218 9241023 418218 9241023 418218 9241088 418218 9241088 418218 9241088 418218 9241088 418218 925093 4140 3853693 417625 2-394488 9221624 2060 9244217 9243888 4060000000000000000000000000000000000 | Deg. | Sine. | 3856377 | 3859060 | 3861744 | 3864427 | 3867110 | 3869792 | 3872474 | 3875156 | 3877837 | 3880518 | 3883199 | 3885880 | 3888560 | 3891240 | 3893919 | 3896598 | 3899277 | 3901955 | 3904633 | 3907311 | | Cosine. | |
| Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Tang. Sine. Cotang. Tang. Tang. Sine. Cotang. Tang. Sine. Cotang. Tang. Sine. Cotang. Tang. Sine. Cotang. Tang. Tang. Sine. Cotang. Tang. Tang. Tang. Sine. Cotang. Tang. Sine. | 22 | - | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | - 09 | 51 | 52 | 53 | 54 | 55 | 99 | 57 | 58 | 59 | 09 | | • | |
| Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. Sine. Sine. Tang. Cotang. Cosine. Sine. | - | 39 | 38 | 37 | 36 | 35 | 34 | 33 | 32 | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | | - | R. |
| Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. 13748763 404026 2-475086 9271839 6021 3802634 4-11149 2-432204 1 3748763 404364 2-473015 9270748 5922 3805324 4-11149 2-432193 2 3751456 4040702 2-46881 9226658 5823 3808014 4-1189 2-430193 2 3751456 4040703 2-470947 9266565 5823 3808014 4-1189 2-4321816 3 375934 4-05719 2-464759 9266380 55 26 3816082 4-12510 2-4218181 6 37623-4-065719 2-464759 9266380 55 26 3816082 4-12861 2-422181 6 37623-4-06570 2-466049 926496 55 26 3816082 4-12861 2-420195 7 376432 4-06576 2-465651 9265006 52 29 3824147 4-13872 2-416201 9 3770327 4-07074 3-426551 9262000 50 31 3829522 4-14524 2-416201 9 3770327 4-07741 2-456551 9262000 50 31 3829522 4-14554 2-416201 1 3775714 4-07753 2-45246 925806 50 31 382952 4-14554 2-416291 1 3778110 4-09431 2-454556 9260902 50 31 382952 4-14554 2-16236 1 3788101 4-09431 2-44835 9255406 45 35 3842953 4-16559 2-406396 1 378810 4-09541 2-44835 9255406 45 35 3842953 4-16559 2-406396 1 3 378910 4-09431 2-44835 9255406 45 35 3842953 4-16559 2-406396 1 3 3789178 4-09490 2-44223 9255301 43 38 3848324 4-16992 2-394488 40 38539944 4-10809 2-43823 9250993 41 40 3853693 4-17625 2-394488 20 377937 3 37793 | | Cosine. | 9248782 | -9247676 | -9246568 | 9245460 | 9244351 | 9243242 | 9242131 | 9241020 | -9239908 | 9238795 | 9237682 | 9236567 | -9235452 | 9234336 | 9233220 | 9232102 | 9230984 | -9229865 | 9228745 | -9227624 | | Sine. | Thor |
| Sine. Tang. Cotang. Cosine. Sine. Tang. 13.0 Deg. Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. Sine. Tang. 1.3748763 404364 2-473015 922070748 5922 3805324 411149 1.3758452 405384 2-473015 92507474 5625 3805324 4111489 2.3754156 405041 2-478917 9266830 5526 3813893 412510 6.3762243 406057 2-465793 9265830 5526 3813893 412510 7.3764298 406396 2-466419 9265286 5427 3818770 413191 7.3764298 406396 2-466419 9265286 5427 3818770 413191 7.3764298 406396 2-466429 9265286 5427 3818770 413191 7.3764298 406396 2-466429 9265286 5427 3818770 413191 10.3775714 407753 2-456551 9262000 5130 3826324 4142187 29.3773021 407741 2-456551 9262000 5130 3826324 414218 11.3775714 407753 2-456429 9256206 523 382895 2-415554 11.3775714 407753 2-456426 9259005 4932 382895 2-415536 11.3775714 407753 2-456425 9256206 6435 3849285 415236 11.3775714 407753 2-456425 9255406 4635 3849285 416259 11.377514 407753 2-45246 925900 6473 3982894 416938 11.377514 407753 2-452320 9255406 4635 3849284 416942 11.37791870 409979 2-442235 9255408 439 3848324 416942 11.37791870 409790 2-442235 9255403 4139 38848324 416942 11.37791870 409790 2-442235 9255403 4139 38848324 416942 11.37791870 409790 2-442235 9255403 4140 3853693 417625 20.3799944 410809 2-433237 9250993 41 40.3853693 417625 20.3799944 410809 2-433217 9249888 40 | | Cotang. | 2.432204 | 2-430193 | 2.428186 | 2.426181 | 2.4 4180 | 2.422181 | 2.420185 | 2.418191 | 2.416201 | 2.414213 | 2.412228 | 2-410246 | 2.408267 | 2.406290 | 2.404316 | 2.402345 | 2.400377 | 2-398411 | 2.396449 | 2.394488 | | | |
| Sine. Tang. Cotang. Cosine. Sine. | | Tang. | 411149 | 411489 | 411830 | 412170 | 412510 | 412851 | 413191 | 413532 | 413872 | 414213 | 414554 | 414895 | 415236 | 415577 | 415918 | 416259 | 416601 | 416942 | 417284 | 417625 | | Cotang. | |
| Sine. Tang. Cotang. Cosine. / / Sine. Tang. Cotang. Cosine. / / / / / / / / / / / / / / / / / / / | Deg. | Sine. | -3802634 | 3805324 | -3808014 | -3810704 | -3813393 | 3816082 | 3818770 | 3821459 | 3824147 | 3826834 | 3829522 | 3832209 | 3834895 | 3837582 | 3840268 | 3842953 | 3845639 | 3848324 | 3851008 | -3853693 | | Cosine. | |
| Sine. Tang. Cotang. Cosine. 1 (1974) (1966) (1974) (1966) (1974) (1966) (1974) (1966) (1974) (1966) (1974) (1966) (1974) (1966) (1974) (1966) | S. | _ | 21 | 22 | 23 | 24 | 25 | 36 | 27 | 28 | 53 | 30 | 31 | 32 | 33 | 34 | 35 | 38 | 37 | 38 | 39 | 40 | | - | |
| Sine. Tang. Cotang. Sine. Tang. Cotang. 3746066 404026 2475086 1.3748763 404364 2475015 2.3751459 404703 2476947 3.3754156 405719 2464759 5.3759547 405719 2464759 6.376622 405719 2464759 7.3764938 406057 2464759 8.376732 407704 2465651 9.3773021 407413 2454565 11 3778794 407704 2465651 12 37881101 408431 2444325 14 3789184 408771 2444325 15 3789187 408771 2444325 16 3789187 408771 2444325 17 3791870 408771 244325 18 3784652 410129 2434217 19 3797253 410469 2436233 20 3799244 410809 2434217 18 410809 2434217 18 410809 434217 18 410809 434217 18 410809 434217 18 410809 434217 18 410809 434217 18 410809 434217 18 410809 434217 18 410809 434217 18 410809 434217 18 410809 434217 18 410808 410808 18 410808 18 410808 18 410808 18 410808 18 410808 18 410808 18 410808 18 410808 18 410808 18 410808 18 410808 18 410808 18 410808 18 410808 18 410808 18 410808 18 410808 18 41 | | Cosine. | 9271839 60 | 9270748 59 | 9269658 58 | 9268566 57 | 9267474 56 | 9266380 55 | 9265286 54 | 9264192 53 | 9263096 52 | 9262000 51 | 9260902 50 | 9259805 49 | 9258706 48 | 9257606 47 | 9256506 46 | 9255405 45 | 9254303 44 | 9253201 43 | 9252097 42 | 9250993 41 | 9249888 40 | Sine. / | Ilan fit |
| Sine. Tang. Sine. Tang. 3746066 -404026 3748763 -404036 3756852 -405380 3756852 -405380 3768243 -406719 3776873 -406735 377027 -406735 377027 -406735 407703 -406735 577027 -406735 577027 -40775 5778101 -40775 5778101 -40843 5778101 -40843 5778101 -40843 5779187 -409450 6779187 -409450 | | Cotang. | 2-475086 | 2-473015 | 2-470947 | 2.468881 | 2.466819 | 2-464759 | 2-462703 | 2.460649 | 2-458598 | 2-456551 | 2.454506 | 2-452464 | 2-450425 | 2-448389 | 2-446355 | 2.444325 | 2-442298 | 2-440273 | 2-438251 | 2-436233 | 2-434217 | - | |
| Sine. Sine. Sine. 3748066 3748763 3748763 3751459 4 3756852 5 3759547 5 376938 6 3762243 6 3762243 11 3777032 11 3777032 12 3778408 12 3778408 12 3778110 4 3783794 5 3789178 6 3789178 6 3789178 7 3789178 8 3794562 8 3794562 8 3794562 8 3794563 8 3799944 6 3760 8 3799944 7 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 | | | 404026 | 404364 | 404703 | 405041 | 405380 | 405719 | 406057 | -406396 | -406735 | 407074 | -407413 | -407753 | -408092 | 408431 | | 409110 | 409450 | -409790 | 410129 | -410469 | -410809 | Cotang. | |
| 28 - 1012884000000000000000000000000000000000 | Jeg. | Sine. | 3746066 | 3748763 | 3751459 | 3754156 | 3756852 | 3759547 | 3762243 | 3764938 | 3767632 | 3770327 | 3773021 | 3775714 | 3778408 | .3781101 | -3783794 | 3786486 | 3789178 | .3791870 | 3794562 | -3797253 | -3799944 | Cosine. | |
| | 22.1 | - | 0 | - | 63 | 8 | 4 | 5 | 9 | 1 | 00 | 6 | 10 | 11 | 12 | 13 | 14 | | 16 | 17 | 18 | 119 | 20 | - | - |

| | - | - | | | | - | | ~ | - | | , | | | - | | - | ~, | - | | | | | | |
|---------|-------------------|--|---|--|--|--|--|--|--|---|--|--|--|--|--|--|---|--|--|--|---|---------------------------------------|-------------------|--------|
| | - | 19 | 18 | 1 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 6 | 00 | 7 | 9 | 5 | 4 | ಯ | C.S | 1 | 0 | | - | 6.0 |
| | Cotang. Cosine. | 0 3907311 424474 2.355852 9205049 6021 3963468 431703 2.316407 9181009 3941 4016814 438622 2.279865 9157795 19 | $3909989 + 248181 \\ 2 \cdot 353948 \cdot 9203912 \cdot 5922 \cdot 3966139 \cdot 432048 \cdot 2 \cdot 314557 \cdot 9179855 \cdot 3842 \cdot 4019478 \cdot 438969 \cdot 278063 \cdot 9156626 \cdot 278063 \cdot 278068 \cdot $ | $\cdot 3912666 \cdot 425161 \cdot 2\cdot 352046 \cdot 9202774 \cdot 5823 \cdot 3968809 \cdot 432393 \cdot 2\cdot 312709 \cdot 9178701 \cdot 3743 \cdot 4022141 \cdot 439316 \cdot 2\cdot 276264 \cdot 9155456 \cdot 3743 \cdot 4022141 \cdot 439316 \cdot 2\cdot 276264 \cdot 9155456 \cdot 3743 \cdot 4022141 \cdot 439316 \cdot 2\cdot 276264 \cdot 9155456 \cdot 3743 \cdot 4022141 \cdot 439316 \cdot 2\cdot 276264 \cdot 9155456 \cdot 3743 \cdot 4022141 \cdot 439316 \cdot 2\cdot 276264 \cdot 9155456 \cdot 3743 \cdot 4022141 \cdot 439316 \cdot 2\cdot 276264 \cdot 9155456 \cdot 3743 \cdot 4022141 \cdot 439316 \cdot 2\cdot 276264 \cdot 3743 \cdot 476264 \cdot 3743 \cdot $ | $3915343 \cdot 425505 \cdot 2350148 \cdot 9201635 \cdot 37124 \cdot 3971479 \cdot 432738 \cdot 2310863 \cdot 9177546 \cdot 3644 \cdot 4024804 \cdot 439663 \cdot 274467 \cdot 9154286 \cdot 274467 \cdot 2746804 \cdot 27467 $ | $3918019 \cdot 425848 \cdot 2\cdot 348251 \cdot 9200496 \cdot 6625 \cdot 3974148 \cdot 433084 \cdot 309020 \cdot 9176391 \cdot 3545 \cdot 4027467 \cdot 440010 \cdot 2\cdot 272672 \cdot 9153115 \cdot $ | 3920699 + 26192 + 26192 + 2949356 + 29199356 + 26926 + 3976818 + 433429 + 307180 + 9175234 + 3446 + 4030129 + 440357 + 270880 + 9151943 + 2919937 + 2919937 + 2919937 + 2919939 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 29199 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 29199 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 29199 + 29199 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 29199 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 29199 + 29199 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 291999 + 29199 | $3923371 \cdot 426536 \\ 2\cdot 344467 \cdot 9198215 \\ 5427 \cdot 3979486 \cdot 433775 \\ 2\cdot 305342 \cdot 9174077 \\ 3317 \cdot 4032791 \cdot 440705 \\ 2\cdot 269090 \cdot 9150770 \\ 3117 \cdot 4032791 \\ 440705 \\ 2\cdot 269090 \cdot 9150770 \\ 3117 \cdot 4032791 \\ 3117 \cdot$ | $3926047 \cdot 426880 \cdot 2.342578 \cdot 9197073 \cdot 5328 \cdot 3982155 \cdot 434120 \cdot 2.303506 \cdot 9172919 \cdot 3248 \cdot 4035453 \cdot 441052 \cdot 267303 \cdot 9149597 \cdot 267303 \cdot 2673000 \cdot 2673000 \cdot 2673000 \cdot 2673000 \cdot 2673000 \cdot 2673000 \cdot 2673000$ | 29 3984823 434466 2.301673 9171760 3149 4038114 441400 2.265518 9148422 | $\cdot 3931397 \cdot 427568 \cdot 2\cdot 338809 \cdot 9194788 \cdot 51 \cdot 30 \cdot 3987491 \cdot 434812 \cdot 2\cdot 299842 \cdot 9170601 \cdot 30 \cdot 50 \cdot 4040775 \cdot 441747 \cdot 2\cdot 263735 \cdot 9147247 \cdot 2017275 \cdot 20172775 \cdot 20172777 \cdot 20172777 \cdot 2017277 \cdot 2017277 \cdot 2017277 \cdot 2017277 \cdot 201727 $ | $3934071\cdot 427912 2\cdot 336928 9193644 50 31 3990158 435158 2\cdot 298014 9169440 29 1\cdot 4043436 442095 2\cdot 261955 9146072 1\cdot 4043436 1\cdot 404346 1\cdot 404366 1\cdot 404666 1\cdot 4046666 1\cdot 4046666 1\cdot 4046666 1\cdot 4046666 1\cdot 4046666 1\cdot 4046666 1\cdot 40466666 1\cdot 404666666 1\cdot 40466666 1\cdot 4046666666 1\cdot 40466666666 1\cdot 4046666666666666666666$ | $1.3936745 \cdot 428256 \cdot 2\cdot335050 \cdot 9192499 \cdot 4932499 \cdot 4935504 \cdot 2\cdot296188 \cdot 9168279 \cdot 286152 \cdot 4046096 \cdot 442443 \cdot 2\cdot260177 \cdot 9144895 \cdot 2\cdot296188 \cdot 2\cdot29618 \cdot 2\cdot29618 \cdot 2\cdot29618 \cdot 2\cdot29618 \cdot 2\cdot296188 \cdot 2\cdot29618 $ | $12\cdot 3939419\cdot 428600 \cdot 2\cdot 333174\cdot 9191353 \cdot 4833 \cdot 3995492\cdot 435850 \cdot 2\cdot 294365\cdot 9167118 \cdot 2753 \cdot 4048756 \cdot 442791 \cdot 2\cdot 258401 \cdot 9143718 \cdot 21848 \cdot 218$ | $13.3942093.4289442.331301\cdot 91902074734\cdot 3998158\cdot 4361962.292544\cdot 91659552654\cdot 4051416\cdot 4431392.256628\cdot 9142540\cdot 9142540\cdot 916293\cdot 428944\cdot 916293\cdot 4289444\cdot 916293\cdot 428944\cdot 916293\cdot 428944\cdot 916293\cdot 428944\cdot 91629344\cdot 916293\cdot 428944\cdot 916293\cdot 428944\cdot 916293\cdot 428944\cdot 91629344\cdot 91629344\cdot 91629344\cdot 91629344\cdot 91629444\cdot 91629344\cdot 916293444\cdot 916293444\cdot 916293444\cdot 91629444\cdot 91629444\cdot 91629444\cdot 91629444\cdot 91629444\cdot 91629444\cdot 91629444\cdot 91629444\cdot 91629444\cdot 916294444\cdot 916294444\cdot 91629444\cdot 91629444\cdot 916294444\cdot $ | -9141361 | -9140181 | -9139001 | $ \begin{array}{c} (7.3952783) \cdot 430323 \cdot 323834 \cdot 9185614 \cdot 42361 \cdot 42362 \cdot 2285284 \cdot 9161297 \cdot 2258 \cdot 4062051 \cdot 444531 \cdot 2249558 \cdot 9137819 \end{array} $ | $18 \cdot 3955455 \cdot 430668 \cdot 2 \cdot 321974 \cdot 9184464 \cdot 42 \cdot 89 \cdot 401 \cdot 1486 \cdot 437928 \cdot 2 \cdot 283475 \cdot 9160130 \cdot 21 \cdot 59 \cdot 4064709 \cdot 444880 \cdot 2 \cdot 247796 \cdot 9136637 \cdot 247796 \cdot $ | $19.3958127 \cdot 431012 \cdot 2\cdot 320116 \cdot 9183313 \cdot 41 \cdot 4014150 \cdot 438275 \cdot 2\cdot 281669 \cdot 9158963 \cdot 20 \cdot 60 \cdot 406736 \cdot 445228 \cdot 2\cdot 246036 \cdot 9135455 \cdot 20 \cdot $ | | Sine. | Dog 68 |
| | | 2.279865 | 2-278063 | 2.276264 | 2-274467 | 2.272672 | 2-270880 | 2-269090 | 2-267303 | 2-265518 | 2-263735 | 2-261955 | 2-260177 | 2.258401 | 2-256628 | 2-254857 | 2.253088 | 2-251322 | 2.249558 | 2.247796 | 2-246036 | | Tang. | |
| | Tang. | 438622 | -438969 | -439316 | ·439663 | .440010 | 440357 | -440705 | -441052 | .441400 | 441747 | .442095 | .442443 | 167274 | 443139 | .443487 | 443835 | -444183 | .444531 | .444880 | .445228 | | Cotang. | 1 |
| 23 Deg. | Sine. | 4016814 | -4019478 | 4022141 | 4024804 | 4027467 | -4030129 | 4032791 | 4035453 | 4038114 | 4040775 | 4043436 | 4046096 | 4048756 | 4051416 | 4054075 | 4056734 | -4059393 | 4062051 | 4064709 | 4067366 | | / Cosine. Cotang. | |
| 23 | | 141 | 342 | 743 | 344 | 545 | 146 | 347 | 848 | 149 | 09 | 19 | 852 | 53 | 554 | 55 | 99 | 157 | 28 | 59 | 09 | | 1 | 1 |
| | - | 98 | 5 38 | 1 37 | 6 36 | 1 35 | 4 34 | 7 3. | 9 35 | 0 3 | 1 30 | 0 29 | 9 28 | 8 27 | 5 26 | 1 25 | 7 24 | 2 23 | 7 22 | 0 21 | 3 20 | | - | 80 |
| | Cosine. | 918100 | -917985 | 917870 | -917754 | -917639 | 917523 | 917407 | -917291 | 917176 | 917060 | -916944 | -016827 | 1117916 | 916595 | 916479 | 916362 | 916246 | 916129 | -916013 | 915896 | | Sine. | Dag Re |
| | Cotang. | 2-316407 | 2-314557 | 2-312709 | 2-310863 | 2-309020 | 2-307180 | 2-305342 | 2-303506 | 2-301673 | 2.299842 | 2.298014 | 2-296188 | 2-294365 | 2.292544 | $14.3944766 \cdot 429289 \cdot 2.329431 \cdot 9189060 \cdot 46 \cdot 35 \cdot 4000826 \cdot 436542 \cdot 2.290725 \cdot 9164791 \cdot 25 \cdot 55 \cdot 4054076 \cdot 443487 \cdot 2.254857 \cdot 9141361 \cdot 918766 \cdot 418767 \cdot 918767 \cdot 91$ | $15 \cdot 3947139 \cdot 429633 \cdot 237563 \cdot 9187912 \cdot 45 \\ 36 \cdot 4003490 \cdot 436889 \cdot 2889999 \cdot 9163627 \cdot 2456 \cdot 4056734 \cdot 443835 \cdot 253088 \cdot 914018 \\ 15 \cdot 3947139 \cdot 429633 \cdot 257563 \cdot 9187912 \cdot 45 \\ 25 \cdot 35 \cdot 3088 \cdot 914018 \cdot 10888 \cdot 10$ | $16 \cdot 3950111 \cdot 429978 \cdot 2325697 \cdot 9186763 \cdot 4487 \cdot 4006156 \cdot 437235 \cdot 2 \cdot 287095 \cdot 9162462 \cdot 2357 \cdot 4059393 \cdot 444183 \cdot 2 \cdot 251322 \cdot 9139001 \cdot 91867 $ | 2.285284 | 2.283475 | 2.281669 | | Tang. | |
| | Tang. | -431703 | -432048 | -432393 | -432738 | 433084 | 433439 | 433775 | 434120 | 434466 | 434812 | 435158 | 435504 | 435850 | 436196 | 436542 | 436889 | 437235 | 437582 | 437928 | 438275 | | Cotang. | |
| 23 Deg. | Sine. | 3963468 | 3966139 | 3968809 | 3971479 | 3974148 | 3976818 | 3979486 | 3982155 | 3984823 | 3987491 | 3990158 | 3992825 | 3995492 | 3998158 | 4000825 | 4003490 | 4006156 | 4008821 | 4011486 | 4014150 | 100 | Cosine. Cotang. | |
| 23 | - | 12 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 35 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | | - | |
| | - | 60 | 59 | 58 | 157 | 99 | 55 | 54 | 53 | 52 | 51 | 50 | 48 | 48 | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 40 | - | 88 |
| | Cosine. | -9205048 | -9203915 | -9202774 | -9201635 | -9200496 | -9199356 | -9198216 | -9197078 | -9195931 | -9194788 | -9193644 | -9192498 | -9191358 | -9190207 | 9189060 | 9187919 | -918676 | -9185614 | -9184464 | 9183318 | 9182161 | Sine. | Dag 66 |
| | Cotang. | 2-355852 | 2-353948 | 2-352046 | 2.350148 | 2.348251 | 2.346358 | 2-344467 | 2-342578 | 2-340692 | 5-338809 | 2-336928 | 2-335050 | 2-333174 | 2-331301 | 2-329431 | 2-327563 | 2-325697 | 3-323834 | 2-321974 | 2.320116 | 2-318260 | Tang. | 1 |
| | Tang. | 424474 | 424818 | 425161 | 425505 | 425848 | 426192 | 426536 | 426880 | 427223 | 427568 | 427912 | 428256 | 428600 | 428944 | 459289 | 429633 | 429978 | 430323 | 430668 | 431012 | 4313 7 | Cotang. | |
| 23 Deg. | Sme. | 3907311 | 3909989 | 3912666 | 3915343 | 3918019 | 3920695 | 3923371 | 3926047 | -3928722 -427223 2-340692 -9195931 52 | 3931397 | 39 34071 | 3936745 | 3939419 | 3942093 | 3944766 | 3947439 | 3950111 | 3952783 | 3955455 | 3958127 | 20 3960798 4313 7 2-318260 9182161 40 | Cosine. Cotang. | |
| 83 | - | 0 | - | Cos. | 8 | 7 | 2 | 9 | 7 | 00 | 6 | 10 | 11 | 12 | 13 | 14 | 15 | 91 | 17 | 181 | 10 | 20 | (- | 1 |

| | | Tables of Sings, Tables 10, 120 | |
|---------|-------------------------|--|--------------------|
| | - | 08700400100870040010 | |
| | Cosine. | 1, 4067366 445228 2246036 9135455 60 21 4123096 452568 2-209611 9110438 3941 4176028 459596 2-175822 9086297 19 4070024 445577 2-244279 9113427 159928 123249 18 2-207901 9109288 3842 417871 459938 2-77455 9085082 18 3 4072537 46527 2-245274 9113902 572 4112845 9226193 910938 3743 4183315 460539 2-774249 9083866 17 3 4077537 446523 2-236724 9113902 572 4113869 2-204549 910837 3644 4183956 46653 2-774249 908324 14 46525 2-24727 9113902 572 4113944 453590 2-20457 910857 3644 4183956 46653 2-774249 908324 14 46527 2-24677 9113902 572 4113869 45950 2-20457 910857 3644 4183956 46653 2-774249 908324 14 46527 2-24677 910857 3644 4183956 46653 2-774249 908324 14 46527 2-24677 910857 3644 4183956 46653 2-23727 912952 5526 4138326 42477 910857 3644 4183956 42476 910857 3644 418395 46652 41138959 46652 41138958 414158 45397 910857 910857 346 4183956 44777 91286 4183956 44777 9128 4183956 44777 9128 4183956 44777 9128 4183956 44777 9128 4183956 44777 9128 4183957 44836 2-23370 4912834 5457 495609 909954 12472 418395 444286 45587 910857 910859 418395 446718 2-228567 912358 465718 2-18258 465718 2-18258 465718 2-18258 465718 2-18258 465718 2-18258 465718 2-18258 465718 2-18258 465718 2-18258 465718 2-18258 465718 46 | Sine. |
| | Tang. Cotang. Cosine. | 1 40670024 4455228 2246036 9135455 60 21 4123096 455268 2·209611 9110438 3941 4176028 459596 2·175822 9085052 2 4072681 445577 2·244279 9134271 59 22 4125745 452918 2·207901 9109238 38 42 4178671 459948 2·174155 9085082 2 4072681 445597 2·245524 9133087 58 23 44128295 4552618 3·168083 3743 4 481313 460301 2·1772441 90882469 3 4075581 446574 2·240777 2 9131902 57 24 4131044 45537 3 2·240487 9 1088356 460653 2·170828 9082649 4 407753 4 407573 2 9131902 55 26 4138632 455370 2·204487 9 106837 36 44 4183956 460662 2·16960 9080214 4 407753 4 406573 2·2337273 9129529 55 26 4138632 4.54331 2·201083 9100432 34 46 4189536 461066 2·169 67 9080214 4 407773 1 2·235528 9128342 54 24 413899 45 45672 2·199384 91032024 32 46 419432 3 46 418989 4 419777 1 2·16859 4 419777 1 419859 4 44732 1 2·235528 9128342 54 444732 2·199384 91032024 32 48 419777 1 2·16854 907654 9 47777 1 47889 4 419777 1 47889 4 41977 1 47889 4 419777 1 47889 4 419777 1 47889 4 419777 1 47889 4 419777 1 47889 4 419777 1 47889 4 419777 1 47889 4 41978 4 41 | Tang. |
| | Tang. | 459596 45948 460633 460653 460653 460653 46065304 465304 465599 465599 465599 | Cotang. |
| 24 Der. | Sine. | 4176028 4178671 41883183 4188595 4186595 4186238 419481 419481 420508 4215396 4215396 4215396 4215396 4215396 4215396 4215396 4215396 4215396 4215396 4215396 | 1 Cosine, ICotang. |
| 24 | _ | 444444444444444444444444444444444444444 | |
| | - | 88588888888888888888 | |
| | Cosine. ' | 9110438 9109238 9106837 9106837 9106438 9104438 9104438 9109411 9099517 9099577 9099578 9099578 9099578 | Sine. |
| | Tang. Cotang. | 1 4070024 4455728 2-246036 9135455 60 21 4123096 452568 2-20611 9110438 39 41 4476028 445577 2-244279 9134271 59 22 4125745 4552918 2-207901 9109238 38 42 447857 2-4077024 445577 2-244279 9134271 59 23 4128395 455269 2-206133 9109238 3743 44183956 4077993 446623 2-239021 913027 58 44128395 455269 2-206133 9106338 3743 44183956 40830649 446972 2-237273 9129529 55 26 4136342 455320 12-201083 9104432 3446 4188395 6 408305 447321 2-237273 9129529 55 26 4186342 4554321 2-201083 91004432 3446 4188395 6 408305 447321 2-235528 9129529 52 418589 456523 2-197687 9102024 3248 419529 6 408305 447321 2-235528 9129529 52 29 416389 456452 2-199384 9102024 3248 419372 14091129 124755 13 0091229 455629 9099613 30 044639 2-25609 9099613 30 044639 455672 2-195994 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099610 2-25609 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099613 30 044639 2-25609 9099613 30 044639 3-25609 9099613 30 044639 3-25609 9099613 30 044639 3-25609 9099613 30 044639 3-25609 9099613 30 044639 3-25609 9099613 30 044639 3-25609 9099613 30 044639 3-25609 9099613 30 044639 3-25609 9099613 30 044639 3-25609 9099613 30 044639 3-25609 9099613 30 044630 3-25609 9099613 30 044639 3-25609 9099613 30 044639 3-25609 9099613 30 044639 3-25609 9099613 30 044639 3-25609 9099613 30 044639 3-25609 9099613 30 044639 3-25609 9099613 30 044639 3-25609 9 | Tang. |
| | Tang. | 452568 452918 453820 453820 453970 454672 455375 455375 455376 456429 456429 456429 456429 456429 456429 456429 456429 456429 456429 456429 456439 456439 456439 456439 456439 | Cotang. |
| 24 Deg. | Sine. | 4123096 4125745 4131044 4133693 41386342 41386342 4144285 4144285 4144285 4144285 4169579 4169679 4166888 4168898 4163898 4163898 4163898 4163898 41638997 4173888 | Cosine, Cotang. |
| 24 1 | - | 1 403 33 33 33 30 1 1 1 1 1 1 1 1 1 1 1 1 1 | 3 |
| - | , | 660 550 550 550 550 550 550 550 550 550 | |
| | Cosine. | 9135455 91345271 9133087 9131902 9131902 9131902 91223342 9122393 9122393 9117620 91116425 9111637 | Sine. |
| | Tang. Cotang. | 4.067366 445228 2.246036 -9135456 60 2.4072024 445577 2.244279 -9134271 59 2.407237 -446577 2.245279 -9134271 59 3.4075337 -44657 2.24524 -9134902 57 4.4077993 -446972 2.237273 -9129529 56 6.4083305 -447321 2.235528 -9128342 54 7.408560 -447321 2.235528 -9128342 54 7.408560 -4477670 2.237273 -9129565 56 9.4091269 -448369 2.23304 -9124775 51 10.409537 -448718 2.228567 -9123584 50 11.4096577 -449068 2.228657 -9123584 50 12.409930 -448718 2.228567 -9123584 50 13.4101883 -44977 2.225 60 0.912120 48 14.4104536 -450147 2.225 643 -911888 54 16.410789 -450467 2.219917 -9117620 45 16.410344 -450517 2.216473 -9116425 44 17.4112492 -451167 2.216473 -9116425 44 18.4113144 -450517 2.216473 -9116425 44 19.4117795 -45167 2.211323 -9111637 40 | Tang. |
| | Tang. | 445228 445577 445624 446623 446623 446623 447321 447321 448718 44917 450417 450417 450417 450417 450417 450417 450417 | Cosine, Cotang. |
| 24 Deg. | Sine. | 1, 4067366 1, 4070024 2, 4072681 3, 4075337 4, 4087619 6, 4083305 6, 408305 6, 4083023 1, 4096577 2, 409323 1, 4096577 2, 409323 1, 4096577 2, 409830 6, 4107189 6, 4107189 6, 4107189 6, 4107189 | Cosine. |
| 24.1 | - | 120 8 4 4 6 5 4 8 8 - 1 | 1 |
| - | - | | |

| Sine Tang. Cotang. Cosine. Sine Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. Cosine | E2 | 25 Deg. | | | | | fact cz | fie | | Section 1 | 1 | | zo neg. | | 1 | | |
|--|-----|-------------|-----------|----------|----------|------|---------|--------|---------|-----------|-----------|-----|-----------|-----------|------------|----------|----|
| 21 -4281467 473765 2.110747 9037093 3941 4333970 480909 2.079394 9012031 12. 4284695 474122 2.109161 9035847 3842 4336591 481267 2.077846 9010770 12. 4286723 474478 2.105995 9033353 3644 4341822 481267 2.077846 9010770 12. 4286723 474478 2.105995 9033353 3644 4341822 481267 2.077846 9010770 12. 4286723 4751911 2.104415 903236 3446 4347072 482701 2.077874 9003246 12. 4291879 4751911 2.104415 903236 3446 4347072 482701 2.077674 9005924 12. 4292937 4751911 2.104415 902836 3244453 482342 2.077824 9006582 12. 42929233 476518 2.09586 9028356 3248 435291 183418 2.065599 90005718 12. 4292723 4.09586 9028356 3248 435774 2.067064 9001921 12. 430771 14. 476975 2.0967064 9028356 3248 435774 2.067064 9001921 13. 430773 14. 476975 2.096497 9028356 3248 435774 2.0660944 899588 32. 4310361 477689 2.093408 9028356 324 436918 4.95572 2.094970 902838 255 436618 4855 2.06400 8999386 32. 4310361 477689 2.093408 902838 255 436018 4855 2.06400 8999386 32. 4310361 47769 2.093408 902838 255 4376634 4855 2.064859 899377 34. 43156 10. 477404 2.090280 902982 255 437663 4855 2.054859 899378 36. 4320857 479477 2.085609 9019582 255 437664 486593 2.057895 8999489 36. 4320857 479477 2.085609 9019582 255 437694 485293 2.056859 9999489 38. 4326103 479947 2.085609 9019580 225 4437482 465092 2.058859 2.0569334 490193 2.082495 9019580 225 4437482 460193 2.0824949 9015810 225 84437482 2.050903 8987940 74331348 480193 2.082495 9013292 206 4383711 487732 2.050903 8987940 740419 2.0809443 9013292 206 7 4383711 487732 2.050903 8987940 740419 2.0809443 9013292 206 7 4383711 487732 2.050903 8987940 740419 2.0809443 9013292 206 7 4383711 487732 2.050903 8987940 740419 2.0809443 9013292 206 7 4383711 487732 2.050903 8987940 740419 2.0809443 9013292 206 7 238371 787732 2.050903 8987940 740410 2.0809443 9013292 206 7 238371 787732 2.050903 8987940 740410 2.0809443 9013292 206 7 238371 787732 2.050903 8987940 740410 2.0809443 740702 2.0809483 740702 2.050903 8987940 740702 2.0809483 740702 2.050903 898794 740702 2.0809483 740702 2.0809483 740702 2.0809088 7407 | 100 | Sine. | Tang. | Cotang. | Cosine. | 1, | | | | | | - | Sine. | l Tang. | | _ | F |
| 22 4284095 474122 2.109161 9035847 38 42 4336591 481267 2.077846 9010770 123 4.286723 474478 2.0777 9044600 3743 4335591 481267 2.077846 9010770 124.4289351 474478 2.07777 9044600 3744 4.341822 4.81842 2.0773214 90063246 125 4.291879 475191 2.104415 9032353 5444 4.341822 4.81842 2.0773214 9006382 125 4.291879 475191 2.104415 9028365 3446 4347072 482701 2.071674 9005718 128 4.2997233 475691 2.101260 902866 3347 4346592 48366 2.07135 900453 128 4.2997233 476618 2.099688 9028356 3248 4352311 483418 2.065599 9003188 128 4.3202485 476618 2.099688 9028356 3248 4352986 43777 2.067064 9001921 139 4302485 476618 2.0996143 9028356 3248 435734 8.64559 2.06400 8999386 32 4310361 477689 2.093408 9028356 324 4360166 484495 2.064000 8999386 32 4310361 477689 2.093408 902834 7855748 484855 2.06400 8999386 32 4315986 478047 2.091843 9028092 275 34365401 485214 2.060944 8996848 34 43156 10 477404 2.090280 9020838 265 4436618 48553 2.057895 8994307 36 432834 478672 2.088709 9019582 255 4370634 485933 2.057895 899336 37 4323481 478472 2.085603 9019582 255 437482 486293 2.056853 9991783 38 432876 440193 2.085603 9019580 258 4437482 480193 2.085408 9015810 2258 4437482 2.050303 8987940 40 4331348 480193 2.082495 9013292 206 6 438371 487732 2.050303 8987940 | 1 | 0 4226183 | 466307 | 2-144506 | 9063078 | 602 | 31.4 | 281467 | 473765 | 2.110747 | -9037093 | 394 | 1 -433397 | 480908 | 2.079394 | -9012031 | 19 |
| 23 4286723 474478 2.107577 9034600 3743 4339212 481625 2.076300 9009508 24-289351 474478 2.105995 903355 3644 434 832 481824 267131 9704415 9002355 3644 434 832 481824 2.07556 9008246 25-4291879 4.75591979 2.105995 9002355 3644 434455 482342 2.073214 9006982 25-4291679 4.75591 2.07519 2.004453 25-4291670 2.071035 9002955 3446 434457 432 43200 2.077135 9002453 25-4299689 4.75504 2.010280 9002956 3347 434699 48306 2.077135 9002453 25-4299859 4.76518 2.099686 9028356 3248 4352311 483418 2.065599 9003188 25-4305111 4776975 2.096543 9025853 3050 4357548 484955 2.064000 8999386 31-4307736 477332 2.096543 9025853 3050 435748 484855 2.064471 8999386 31-4307736 477332 2.0994976 902309 2753 4365401 485214 2.060944 8996848 34-4315610 477892 2.099496 902393 2.55 4365401 485214 2.060944 8996848 34-4315610 477892 2.087161 9019323 2.55 437896 48855 2.064471 89996848 34-4315610 4778404 2.09280 90280 2.55 4376804 485512 2.059418 8995258 34-332349 477477 2.085649 9015810 2.55 437866 48665 2.068853 899376 34-332349 477477 2.085649 9015810 2.55 437896 4887372 2.051818 8999215 40-4331348 480551 2.080943 9013292 2.060 4388711 487773 2.050303 8987940 43226103 477832 2.084048 9015810 2.258 4378482 487732 2.051818 8989215 40-4331348 480551 2.080943 9013292 2.060 4388711 487773 2.050303 8987940 43326106 Cotang. Tang. Sine. | | 1 -4228819 | 1466661 | 2.142879 | -9061848 | 59 2 | 22 4 | 284095 | 474122 | 2.109161 | -9035847 | 384 | 2 -433659 | 1 481267 | 2.077846 | 9010770 | 18 |
| 24 -4289351 474834 2.105995 9033353 3644 -4341832 481984 2.074756 9908246 1 25 -4291879 4751912 -104415 9022105 3545 -434453 -482342 2.072314 -990892 1 26 -4294606 -475548 2.102836 93446 -434453 -482342 2.072314 -9906982 1 28 -42994606 -475548 2.102836 9902856 3347 -434692 -483701 2.071674 9905718 1 28 -4299859 476861 2.099686 9902856 3347 -434692 -483060 2.077135 -9904453 1 28 -435984 -475972 2.094975 -990286 9028356 3248 -435231 -48317 2.067064 -9901921 30 -4302485 -476975 2.094975 -9025853 3050 -435774 -48495 2.066944 -899386 31 -4307736 -477332 2.094975 -902585 3050 -436748 -484855 2.065447 -899386 31 -4315610 -478404 2.091843 -902092 2753 -4365401 -48551 2.059418 -8995578 34 -4315610 -478404 2.09280 -902083 265 -436801 -48551 2.059418 -8995578 34 -431286 -4789119 -208716 1 -901832 2.55 -437683 -48593 2.057895 -9994307 36 -4323481 -479717 2.087161 -901832 2.55 -437686 -48655 2.06878 -8999763 37 -4323481 -479477 2.087161 -901832 2.55 -437886 -48652 2.058718 -89990489 39 -43233481 -479477 2.08569 30 10768 2.57 -437886 -48652 2.058761 -89580 2.59 -43881348 -480551 2.080443 -901329 2.06 -4388711 -487732 2.051818 -8989215 40 -43331348 -480551 2.080943 -9013292 2.06 -4388711 -487732 2.05030 -8987940 | | 2 4231455 | 9-467016 | 2-141253 | 8190906 | 585 | 23 4 | 286723 | 474478 | 2-107577 | -9034600 | 374 | 3 433921 | 2 481625 | 2-076300 | 8096006- | 17 |
| 25 4291979 475191 2-104415 9032105 3545 -4344453 -482342 2-073214 9006982 1 56 4294606 475548 2-02886 9039856 3446 -434772 -482701 2-071674 -9006982 1 27 4294506 475548 2-02886 9029606 3344 -4345692 -483701 2-071674 -9006188 1 29 4302485 476618 2-099686 9029606 3348 -4352311 -483717 2-067064 -9001921 1 30 4305111 -476975 2-096543 9025853 3050 -435751 2-086599 90003 483 1 43036111 -476975 2-094675 9024600 2951 -4369016 -484855 2-06531 9000654 1 31 4307736 -477689 2-094475 9002400 2951 -4366401 -485214 2-066944 -8998664 5 3 4312986 477647 2-091843 -902292 2753 -4365401 -485214 2-069448 -8998648 3 4-312986 477647 2-091843 -902092 2753 -4365401 -485214 2-059418 -8998578 3 4312986 477647 2-091843 -902938 2654 -4368018 -48593 2-0589418 -8998578 3 4312986 477647 2-087161 -901832 2-056431 -48593 2-057895 -899407 3 6 4322803 2-05493 -9017068 235 7-437586 -486652 2-054853 8-999763 3 9 4328103 477835 2-056334 -8999489 3 9 4328103 478935 2-056494 -901832 2-056498 -901832 2-056497 -487732 2-051818 -8989215 40 4331348 -480551 2-080943 -9013292 2-06-4383711 -487732 2-050303 -8987940 | | 3 -423-1090 | 467370 | 2.139630 | 9866906 | 57 5 | 24 .4 | 198688 | 474834 | 2.105995 | -9033353 | 364 | 4 -434183 | 2 481984 | 2.074756 | 9008346 | 16 |
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| 29 4302485 476618 2-098114 9027105 3149 4354930 483777 2-067064 990 4302485 476618 2-098543 9025563 3050 4357548 484186 2-065531 900 435111 476732 2-094975 2-094600 2951 4360166 484495 2-064000 893 4312386 477332 2-094975 9024600 2951 436016 484495 2-064000 893 4312386 477892 9093408 9023347 2852 4365784 484555 2-064000 893 4312510 4778404 2-090280 902083 2654 4368018 485573 2-059418 893 4318234 477872 2-051843 90280 2555 4370634 485533 2-059418 893 43285103 47782 2-08720 901580 2557 437586 486552 2-054853 893 4328103 477835 2-084048 901580 0 258 4378511 487732 2-051818 893 4328726 480193 2-082495 9013292 20 60 4383711 487732 2-050303 893 43331348 480551 2-080943 9013292 20 60 4383711 487732 2-050303 893 43331348 480551 2-080943 9013292 20 60 4383711 487732 2-050303 893 43331348 480551 2-080943 9013292 20 60 4383711 487732 2-050303 893 43331348 480551 2-080943 9013292 20 60 4383711 487732 2-050303 893 43331348 480551 2-080943 9013292 20 60 4383711 487732 2-050303 893 43331348 480551 2-080943 9013292 20 60 4383711 487732 2-050303 893 43331348 480551 2-080943 9013292 20 60 4383711 487732 2-050303 893 43331348 480551 2-080943 9013292 20 60 4383711 487732 2-050303 893 43331348 480551 2-080943 9013292 20 60 4383711 487732 2-050303 893 4333148 480551 2-080943 9013292 20 60 4383711 487732 2-050303 893 4333148 480551 2-080943 9013292 20 60 4383711 487732 2-050303 893 4333148 480551 2-080943 9013292 20 60 4383711 487732 2-050303 893 4333148 480551 2-080943 9013292 20 60 4383711 487732 2-050303 893 4333148 480501 2-080943 9013295 20 60 4383711 487732 2-050303 893 433314 893 4333148 480501 2-080843 9013295 20 60 4383711 487732 2-050303 893 4333148 480501 2-080843 9013295 20 60 4383711 487732 2-050303 893 433314 893 4333 | | 7 -4244628 | 468789 | 2-133155 | 9054454 | 53 | 58 4 | 698668 | 476261 | 2-099686 | -9028356 | 324 | 8 435231 | 1 -483418 | 669890-8 | 8818006 | 12 |
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| 38 4326103 479835 2-084048 9015610 2258 4378482 487012 2-053334 89 39 4328726 480193 2-082495 9014551 2159 4381097 487732 2-050303 89 40 4331348 480551 2-080943 9013292 20 60 4383711 487732 2-050303 89 | | 6 -4268318 | 471986 | 2.118705 | -9043310 | 448 | F. 78 | 323481 | 479477 | 2.085603 | -9017068 | 23 | 7 437586 | 6 -486652 | 2.054853 | 8991763 | 3 |
| 39 4328726 480193 2-082495 9014551 21 59 4381097 487372 2-051818 -89 40 4331348 480551 2-080943 9013292 20 60 4383711 487732 2-050303 -89 Cosine Cotang. Tang. Sine. Cosine. Cotang. Tang. | | 7 -4270949 | 472342 | 2-117110 | -9042068 | 43 | 18 4 | 326103 | 479835 | 2.084048 | -9015810 | 222 | 8 437848 | 2 487012 | 2.053334 | -8990489 | 63 |
| 40 4331348 480551 2.080943 9013292 20 60 4383711 487732 2.050303 -89 | | 8 -4273579 | 472697 | 2.115516 | -9040825 | 428 | 39 4 | 328726 | 480193 | 2.082495 | 19014551 | 215 | 9 438109 | 7 487372 | 2.051818 | 8989215 | - |
| Cosine Cotang. Tang. Sine. / / Cosine. Cotang. Tang. | | 9-4276208 | 473053 | 2.113924 | -9039582 | 414 | 10 4 | 331348 | 480551 | 2.080943 | -9013292 | 206 | 0 438371 | 1 -487732 | 2-050303 | 8987940 | 9 |
| Tang. Sine. / / Cosine Cotang. Tang. Sine. / / Cosine. Cotang. Tang. | | 0.4278838 | 473409 | 2-112334 | -9038338 | 40 | | | | | | | | | | | |
| | | Cosine. | Cotang. | | Sine. | ~ | 10 | | Cotang. | - | Sine. | - | Cosine | Cotang | | Sine. | - |
| | | | | | | 1 | | | 1 | | 2 | 1 | | | | n u | l. |

NATURAL SINES AND TANGENTS TO A RADIUS 1.

| 1 | - | 6 | 20 8 | - | 0 4 | 0 4 | . 60 | C.S. | 1 | 0 | 6 | 90 | 7 | 9 | 2 | 9 | 80 | 90 | - | 0 | 1 | - | - |
|---------|-----------------|--|---|--|--|---|---|--|--|--|--|---|---|---|--|---|---|--|--|---|---------------------------------------|-----------------|----------|
| | Cosine. | 1000 | 8933714 | 8932406 | 8931098 | 1.983969 8939690 | 89271691 | 1.979663 89258581 | 8924546 | 8923234 | 8921920 | 8920606 | 1626168- | 8917975 | 8916659 | 8915342 | 8914024 | 8912705 | 8911385 | 8910062 | 1 | Sine | Dec. 63. |
| | Colang. | -4490591 -502583 1-989720 -8935021 | 1.988278 | 1.9868381 | 1.985400 | 1.9833963 | 1.981095 8927169 | 1.979663 | 1.978233 8924546 | 1-976805 | 1-975378 8921920 | 1.973953 8920606 | 1-972529 | 1-971107 | 1.969687 | 1.968268 | 1.966851 | 1.965436 | 1-964022 | 1.962610 | | Tang. | |
| | Tang. | -502583 | 502947 | ·503312 | 503676 | 150404 | 504771 | 505136 | -505501 | -505866 | -506232 | -506597 | -506963 | -507329 | -507694 | .508060 | .508426 | -508792 | -509159 | 509525 | | Cotang. | |
| 26 Deg. | Sine. | 4490591 | 4493190 | 4495789 | 4498387 | 4500984 | 4506179 | 4508775 | 4511372 | 4513967 | 4516563 | 4519158 | 4521753 | 4524347 | 4526941 | 4529535 | 4532128 | 4534721 | 4537313 | 4539905 | 1 | Cosine, Cotang. | |
| 56 | _ | 941 | 12 | 13 | 44 | 010 | 170 | 18 | 61 | 020 | 12 | 52 | 753 | 564 | 55 | 99 | 357 | 258 | 69 | 109 | | 1 | - |
| | Cosine. | 8960994 39 | 8959703 38 | 89584113 | 8957118 3 | 8955824 3 | 8953934 33 | 8951938 33 | 89506413 | 8949344 30 | 8948045 28 | 8946746 28 | 8945446 27 | 8944146 26 | 8942844 28 | 8941542 24 | 8940240 2: | 8938936 25 | 8937632 21 | 8936326 20 | | Sine. | Dog. 63 |
| | Tang. Cotang. | 2-018908 | 2.017433 | 2.015959 | 2.014486 | 2-013016 | 2.011547 | 2-008615 | 2-007151 | 2-005689 | 2.004229 | 2.002771 | 2.001314 | 1.9998591 | 1-9984051 | 1-996953 | 1-995503 | 1-994055 | 1.992608 | 1.991163 | | Tang. | |
| 1 | Tang. | 495317 | 495679 | 496041 | 496404 | 992965 | 497129 | 497855 | 498218 | 182864 | 498944 | 499308 | 499671 | 5000035 | -500398 | 500762 | 501126 | -501490 | -501854 | 502218 | | Cotang. | |
| 26 Deg. | Sine. | 4438531 | 4441140 | 4443746 | 4446352 | 4448957 | 4451562 | 4456771 | 4459375 | 4461978 | 4464581 | 4467184 | 4469786 | 4472388 | 4474990 | 4477591 | 4480192 | 4482792 | 4485392 | 4487992 | | Cosine. Cotang. | |
| 98 | _ | 21 | 22 | 823 | 724 | 325 | 926 | 28 | 29 | 30 | 31 | 35 | 333 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | | - | ı |
| | Cosine. / | 0-4383711 -487732 2-050303 8987940 6021 -4438534 -495317 2-018908 8960994 3941 | 4386326 488092 2.048791 8986665 59 22 4441140 495679 2.017433 8959703 38 42 4493190 502947 1.988278 8933114 | -4388940 -488453 2-047280 -8985389 58,23 -4443746 -496041 2-015959 -8958411 3713 -449789 -5033121-986838 -895406 | -4391553 -488813 2-045770 -8984112 57/24 -4446352 -496404 2-014486 -895718 3 4 4-498387 -503676 1-98540 -8931098 | 4394166 489173 2.044263 8982834 5625 4448957 496766 2-013016 8955824 35 16 450041 | 4.396779 4.896574 2 0.427757 8891 555 5526 4.445 1.524 4.471 2.49 4.70 1.54 4.7 (2.49 4.70 4.70 4.70 4.70 4.70 4.70 4.70 4.70 | 4.593939, 493094, 4041-4020, 4040-401, 4040-40 | 4404815 406616 2-038251 89777715 5229 4459375 498218 2-007151 8950641 31 19 4511372 505501 | -4461978 - 49657 - 490977 - 2036753 - 8976433 - 5130 - 4461978 - 498581 - 2005689 - 8949344 - 3050 - 4513967 - 505866 - 1976805 - 4461978 - 4461 | 4409838 49 338 2-035256 8975151 50 31 4464581 498944 2.004229 8948045 29 51 4516563 506232 1 | -441 2448 -491699 2-033761 -8973868 4932 -4467184 -499308 2-002771 -8946746 2852 -4519158 -506597 1 | 44 15059 492661 2-032268 8972584 4833 4469786 499671 2-001314 8945446 27 53 4521753 5C6963 1-972529 | -4417668-49422-2-030776-8971299-4734-4472388-500035-1-999859-8944146-26-4524347-507329-1-971107 | -420278 + 92783 + 202287 + 8970014 + 635 + 4474990 + 500398 + 198428 + 420278 + 42 | 5.4422887.493145 $2.027799 + 8968727 + 4536 + 4477591 + 500762 + 996953 + 8941542 + 2452987 + 93145 + 529535 + 508060 + 968268 + 8915342$ | $6.4455496.4935072.026313.8967440.4437.4480192.501126 \\ 1.995503.8940240.2357.4532128.508426 \\ 1.966851.26840.240.2357.4532128.508426 \\ 1.966851.28840.240.2357.4532128.508426 \\ 1.966851.28840.240.2357.4532128.508426 \\ 1.966851.28840.240.240.2357.4532128.508426 \\ 1.966851.28840.240.240.2357.4532128.508426 \\ 1.966851.28840.240.240.2357.48810.28840.240.240.240.240.240.240.240.240.240.2$ | -4428104 - 493868 - 2024828 - 8966153 + 338 - 4482792 - 501490 + 994055 - 8938936 + 2258 - 4534721 - 508792 + 965436 - 8912705 - 8938936 + 2628792 + 26287 | -4430712 -494230 -23346 -8964864 -4265392 -501854 -992608 -8937632 -159 -4537313 -509159 -509158 | $19.4433319.494592 \\ 2.021865 \cdot 8963575 \\ 4140 \cdot 4487992 \cdot 502218 \\ 1.991163 \cdot 8936326 \\ 2060 \cdot 4539905 \cdot 509525 \\ 1.962610 \cdot 8910065 \\ 2060 \cdot 4539905 \cdot 509525 \\ 1.962610 \cdot 8910065 \\ 2060 \cdot 4539905 \cdot 509525 \\ 1.962610 \cdot 8910065 \\ 2060 \cdot 4539905 \cdot 509525 \\ 2060 \cdot 453905 \cdot 509505 \\ 2060 \cdot 453905 \\ 2060 \cdot$ | 20 4435927 494954 2.020386 8962285 40 | Sine. | Dag 62 |
| - | Tang. Cotang. | 2.050303 | 2.048791 | 2.047280 | 2.045770 | 2.044263 | 2 042757 | 9.030751 | 2.038251 | 2.036753 | 2.035256 | 2-033761 | 2.032268 | 2-030776 | 2.029287 | 2.027799 | 2.026313 | 2.024828 | 2-023346 | 2.021865 | 2-020386 | Tang. | |
| | Tang. | 487732 | 488092 | -488453 | 488813 | 489173 | 489534 | 469694 | 490616 | 490977 | 491338 | 491699 | 492061 | 492422 | 492783 | 493145 | 493507 | 493868 | 494230 | 494592 | 494954 | Cotang. | |
| eg. | Sine. | 1383711 | 1386326 | 1388940 | 1391553 | 4394166 | 4396779 | 1409004 | 1404615 | 1407997 | 1409838 | 1419448 | 1415059 | 1417668 | 1420278 | 1422887 | 1425496 | 1428104 | 4430712 | 4433319 | 4435927 | Cosine. | |
| 26 Deg. | - | 10 | - | CS | 3 | 4 | 0 | 10 | - 0 | 0 | 10 | 11 | 120 | | 14 | 15 | 16 | 17 | 18 | 19 | 50 | 1- | 1 |

NATURAL SINES AND TANGENTS TO A RADIUS 1.

| | et Deg. | | | | 9 | - | The Party and Street, or other Persons | 1 | - | ı | | - | - | - | i |
|-----|---------|---------|----------|--|-------|-----------------|--|----------|---------|-------|-------------------|---------|---------------|----------|------|
| 00 | Sine. | Tang. | Cotang. | Cosine. | 1 | Sine. | Tang. | Cotang. | Cosine | 1 | Sine. | Tang. | Tang. Cotang. | Cosine. | K. 1 |
| ico | 39905 | 509525 | 1.962610 | 4539905 539525 1-962610 8910.65 6021 4594248 517244 1-933323 8882166 3941 4645845 524640 1-906066 8855288 19 | 100 | -4594248 | 517244 | 1-933323 | 8882166 | 39 41 | 4645845 | -524640 | 1-906066 | 8825588 | 19 |
| 5 | 12497 | 168609 | 1.961200 | $.4542497 \cdot 579891 \cdot 1961200 \cdot 8908744 \cdot 59 \cdot 22 \cdot 4596832 \cdot 517612 \cdot 1931945 \cdot 8880830 \cdot 3842 \cdot 4648420 \cdot 525011 \cdot 1904719 \cdot 8853936 \cdot 188739 \cdot 198858930 \cdot 19885890 \cdot 198$ | 9 22 | 4596832 | -517612 | 1-931945 | 8880830 | 38 42 | -4648420 | -525011 | 1.904719 | 8853936 | 18 |
| 5 | 88091 | 510258 | 1-959791 | $.4545088 \cdot 5102581 \cdot 959791 \cdot 8907423 \cdot 88293 \cdot 4599415 \cdot 517981 \cdot 1 \cdot 930569 \cdot 8879492 \cdot 37143 \cdot 4650996 \cdot 5253821 \cdot 903373 \cdot 8852584 \cdot 8879492 \cdot 37143 \cdot 4650996 \cdot 5253821 \cdot 903373 \cdot 8852584 \cdot 8879492 \cdot 37143 \cdot 4650996 \cdot 5253821 \cdot 903373 \cdot 8852584 \cdot 38879492 \cdot 37143 \cdot 4650996 \cdot 525382 \cdot 388794 \cdot $ | 8 23 | 4599415 | -517981 | 1.930569 | 8879492 | 37 43 | -4650996 | .525382 | 1,903373 | -8852584 | 17 |
| 5 | 17679 | -510625 | 1.958383 | $-4547679 \cdot 510625 \cdot 1958383 \cdot 8906100 \cdot 5724 \cdot 4601998 \cdot 518350 \cdot 1929195 \cdot 8878154 \cdot 36144 \cdot 4653571 \cdot 525754 \cdot 192029 \cdot 8851230 \cdot 1667679 \cdot 1967679 \cdot 19$ | 1724 | -4601998 | .518350 | 1.929195 | 8878154 | 36 14 | -4653571 | -525754 | 1-902029 | 8851230 | 16 |
| 2 | 50269 | -510991 | 1-956978 | $4550269 \cdot 510991 \mid 1.956978 \cdot 8904777 \mid 5625 \mid 4604580 \cdot 518719 \mid 1.927822 \cdot 8876815 \mid 3545 \cdot 4656145 \cdot 526125 \mid 1.90687 \mid 8849876 \mid 158849876 \mid 158848876 \mid 15884876 \mid 158848876 \mid 15884876 \mid 158848876 \mid 15884876 \mid 158$ | 6 25 | -4604580 | -518719 | 1.927822 | 8876815 | 35 45 | 4656145 | -526125 | 1 900687 | 8849876 | 15 |
| 5 | 52859 | -511358 | 1-955573 | $4552859 \cdot 511358 \cdot 1955573 \cdot 8903453 \cdot 5526 \cdot 4607162 \cdot 519089 \cdot 1926451 \cdot 8875475 \cdot 3446 \cdot 4658719 \cdot 526496 \cdot 1899346 \cdot 8848522 \cdot 14899346 \cdot 1889346 \cdot 18$ | 55 26 | -4607162 | .519089 | 1.926451 | 8875475 | 34 46 | 4658719 | -526496 | 1.899346 | 8848522 | 14 |
| C | 55449 | -511725 | 1.954171 | $4555449 \cdot 511725 \cdot 1.951171 \cdot 9302128 \cdot 5427 \cdot 4609744 \cdot 519458 \cdot 1.925081 \cdot 8874134 \cdot 3317 \cdot 4661293 \cdot 526868 \cdot 1.898006 \cdot 8847166 \cdot 1.898006 \cdot 1.89800$ | 4 27 | 4609744 | -519458 | 1.925081 | 8874134 | 33 47 | -4661293 | .526868 | 1.898006 | 8847166 | 13 |
| 5 | 58038 | .5 2093 | 1.952770 | $4558038 \cdot 5 \times 2093 \cdot 1 \cdot 952770 \cdot 8900803 \cdot 5328 \cdot 4612325 \cdot 519827 \cdot 1 \cdot 923713 \cdot 8872793 \cdot 3218 \cdot 4663866 \cdot 527240 \cdot 1 \cdot 896668 \cdot 8845810 \cdot 12 \cdot $ | 3 28 | 4612325 | 519827 | 1.923713 | 8872793 | 32 18 | 4663866 | .527240 | 1.896668 | 8845810 | 12 |
| NO. | 60627 | .512460 | 1.951371 | $-4560627 \cdot 512460 \cdot 1951371 \cdot 8899476 \cdot 5229 \cdot 4614906 \cdot 520197 \cdot 1922347 \cdot 8871451 \cdot 31149 \cdot 4666439 \cdot 527612 \cdot 1\cdot 895332 \cdot 8844453 \cdot 100000000000000000000000000000000000$ | 52 29 | -4614936 | -520197 | 1.922347 | 8871451 | 31 49 | 4666439 | .527612 | 1-895332 | 8844453 | 11 |
| NG | 63216 | 512827 | 1.949973 | $-4563216 \cdot 512827 \cdot 1949973 \cdot 8898149 \cdot 51 \cdot 30 \cdot 4617486 \cdot 520567 \cdot 1920982 \cdot 8870108 \cdot 3050 \cdot 4669012 \cdot 527983 \cdot 1893997 \cdot 8843095 \cdot 19887 | 51 30 | -4617486 | -520567 | 1.920982 | 8870108 | 30 50 | 4669012 | .527983 | 1-893997 | 8843095 | 10 |
| 10 | 65804 | -513195 | 1-948577 | $0.4565804 \cdot 513195 1 \cdot 948577 \cdot 8896522 \cdot 50 \\ 31.4620066 \cdot 520936 \\ 1 \cdot 919618 \cdot 8868765 \\ 29671 \cdot 4671584 \cdot 528356 \\ 1 \cdot 892663 \\ 1 \cdot 89263 \\ 1 \cdot 892663 \\ 1 \cdot 892663 \\ 1 \cdot 892663 \\ 1 \cdot 892663 \\ 1 \cdot 89263 \\ 1 \cdot 892663 \\ 1 \cdot 892663 \\ 1 \cdot 892663 \\ 1 \cdot 892663 \\ 1 \cdot 89263 \\ 1 \cdot 892663 \\ 1 \cdot 892663 \\ 1 \cdot 892663 \\ 1 \cdot 892663 \\ 1 \cdot 89263 \\ 1 \cdot 892663 \\ 1 \cdot 892663 \\ 1 \cdot 892663 \\ 1 \cdot 892663 \\ 1 \cdot 89263 \\ 1 \cdot 892663 \\ 1 \cdot 892663 \\ 1 \cdot 892663 \\ 1 \cdot 892663 \\ 1 \cdot 89263 \\ 1 \cdot 892663 \\ 1 \cdot 892663 \\ 1 \cdot 892663 \\ 1 \cdot 892663 \\ 1 \cdot 89263 \\ 1 \cdot 892663 \\ 1 \cdot 892663 \\ 1 \cdot 892663 \\ 1 \cdot 892663 \\ 1 \cdot 89263 \\ 1 \cdot 892663 \\ 1 \cdot 89263 \\ 1 \cdot $ | 50 31 | -4620066 | .520936 | 1.919618 | 8868765 | 29 51 | -4671584 | -528356 | 1-892663 | 8841736 | 6 |
| 10 | 68392 | -513562 | 1.947182 | $1.4568392 \cdot 513562 \cdot 1.947182 \cdot 8895493 \cdot 4932 \cdot 4622646 \cdot 521306 \cdot 1.918256 \cdot 8867420 \cdot 2852 \cdot 4674156 \cdot 528728 \cdot 1.891331 \cdot 8840377 \cdot 1.8816377 \cdot 1.881677 \cdot 1.88$ | 9 32 | -1622646 | -521306 | 1.918256 | 8867420 | 28 52 | 4674156 | .528728 | 1.891331 | 8840377 | 00 |
| 5 | 62607 | -513930 | 1.945789 | $2.4570379 \cdot 513930 \cdot 1945789 \cdot \times 894164 \cdot 4833 \cdot 4625225 \cdot 521676 \cdot 1 \cdot 916896 \cdot 8866075 \cdot 2753 \cdot 4676727 \cdot 529100 \cdot 1 \cdot 890000 \cdot 8839017 \cdot 1 \cdot$ | 8 33 | .4625225 | -521676 | 1.916896 | 8866075 | 27 53 | 4676727 | -529100 | 1.890000 | 8839017 | 7 |
| 5 | 73566 | -514298 | 1-944398 | $13.4573566 \cdot 514298 \cdot 1.944398 \cdot 8892834 \cdot 47 \cdot 34 \cdot 4627804 \cdot 522.346 \cdot 1.915537 \cdot 8864730 \cdot 2654 \cdot 4679298 \cdot 529472 \cdot 1.888671 \cdot$ | 7 34 | 4627804 | -522346 | 1-915537 | 8864730 | 26 54 | .4679298 | -529472 | 1.888671 | 8837656 | 9 |
| 5 | 76153 | -514665 | 1.943008 | $4.4576153 \cdot 514665 1.943008 \cdot 8891503 \cdot 46 35.4630382 \cdot 522117 1.914179 \cdot 8863383 2555 \cdot 4681869 \cdot 529845 1.887343 8836295 1.8873434 1.887343 1.887343 1.887343 1.887343 1.887343 1.8$ | 6 35 | -4630382 | .522117 | 1-914179 | 8863383 | 25 55 | -4681869 | -529845 | 1-887343 | 8836295 | 2 |
| 10 | 78739 | -515033 | 1.941620 | $5.4578739 \cdot 515033 \cdot 941620 \cdot 8890171 \cdot 4536 \cdot 4632960 \cdot 522787 \cdot 1 \cdot 912823 \cdot 8862036 \cdot 2456 \cdot 4684439 \cdot 530217 \cdot 1886017 \cdot 8834933 \cdot 8834938 \cdot 2456 \cdot 24$ | 5 36 | -4632960 | -522787 | 1.912823 | 8862036 | 2456 | 4684439 | -530217 | 1.886017 | 8834933 | 4 |
| 5 | 81325 | -515401 | 1.940233 | $\{6.4581325\cdot 515401 \mid 1\cdot 940233 \cdot 8888839 \mid 44 \mid 37\cdot 4635528\cdot 523157 \mid 1\cdot 911469\cdot 8860688 \mid 2357\cdot 4687009 \cdot 530590 \mid 1\cdot 884692 \mid 8833569 \mid 1\cdot 884692 \mid 8833569 \mid 1\cdot 888888 \mid 11\cdot 8888888 \mid 11\cdot 8888888888$ | 4 37 | 4635538 | -523157 | 1.911469 | 8890988 | 23 57 | -4687009 | -530590 | 1.884692 | 8833569 | 3 |
| 5 | 83910 | -515770 | 1.938848 | $7.4583910 \cdot 515770 \cdot 1.938848 \cdot 8887506 \cdot 438155 \cdot 523528 \cdot 1.910116 \cdot 8859339 \cdot 2258 \cdot 4689578 \cdot 530963 \cdot 1.883369 \cdot 8832206 \cdot 1.910116 \cdot 1.$ | 3 38 | 4638115 | -523528 | 1.910116 | 8859339 | 22 58 | -4689578 | -530963 | 1-883369 | 8832206 | 67 |
| 5 | 86496 | -516138 | 1.937464 | $18.4586496.516138 \\ 1.937464.988617242 \\ 39.4640692 \\ 1.523899 \\ 1.908764 \\ 1.9887989 \\ 21 \\ 5914692147 \\ 1.531336 \\ 1.882017 \\ 1.883084 \\ 1.883084 \\ 1.882017 \\ 1.883084 \\ 1.882017 \\ 1.883084 \\ 1.882017 \\ 1.883084 \\ 1.882017 \\ 1.883084 \\ 1.882017 \\ 1.882017 \\ 1.883084 \\ 1.882017 \\ 1.883084 \\ 1.883084 \\ 1.882017 \\ 1.883084 \\ 1.882017 \\ 1.883084 \\ 1.88308 \\ 1.883$ | 2 39 | 4640692 | -523899 | 1-908764 | 8857989 | 51 59 | 4692147 | -531336 | 1.882017 | 8830841 | 1 |
| 5 | 08068 | -516506 | 1.936082 | $19^{-4}589080 \cdot 516506 \cdot 1936082 \cdot 8884838 \cdot 41 \cdot 10 \cdot 4643269 \cdot 524269 \cdot 1907414 \cdot 8856639 \cdot 20 \cdot 60 \cdot 4694716 \cdot 531709 \cdot 1880726 \cdot 8829476 \cdot 10 \cdot 1$ | 1 40 | 4643269 | .524269 | 1-907414 | 8826639 | 09 03 | 4694716 | -531709 | 1.880726 | 8829476 | 0 |
| 15 | 91665 | -516875 | 1-934702 | 20 4591665 516875 1-934702 8883503 40 | 0 | | | | | - | | | 1 | | - |
| 5 | Cogne. | Cotang. | Tang. | Sine. | - | Cosine. Cotang. | Cotang. | Tang. | Sine. | , , | / Cosine. Cotang. | Cotang. | Tang. | Sine. | - |
| | | | п | 00 | 1 | | | | Dag 69 | | | | | D. 00 | 00 |

Deg. 61.

Deg. 61.

NATURAL SINES AND TANGENTS TO A RADIUS ..

| 28 Deg. Sinc. Tang. Cotang. Cosine. / Sinc. Tung. Cotang. Cosine. / Sinc. Sin | | ' Cosine, Cotang, Tang, Sine, ' |
|--|--|---------------------------------|
| Cotang. -827799 -826537 -822759 -822759 -821502 -820247 -818993 -817440 | 816489 -815239 -815239 -812743 -810252 -8010252 -807766 -8065286 | |
| 827799 826537 826537 8226117 822759 821502 821502 | 816489 -815239 -815239 -812743 -810252 -8010252 -807766 -8065286 | ptang. Tang. |
| ine. Tang. 19683 -547106 12235 -547106 14786 -547864 14786 -5478640 19888 -5488 -64891 1988 -5489 -54891 1987 -54997 1987 -549975 1987 -549975 1987 -549975 | 34 050512 32 050811 30 051270 31 0551270 31 055202 32 05328 32 05328 32 05328 | stang. |
| ine. 19683 14786 17337 19888 1988 14987 17537 | 48874568786 | Ö |
| 483 488 488 488 488 488 488 488 488 488 | 50 4822634 51 4825183 53 4827730 54 4832834 56 4835370 56 4837916 57 4840463 58 4848007 69 4848696 | Cosine. |
| 41 479 43 480 44 480 45 480 46 481 47 481 48 481 | 0.0000000000000000000000000000000000000 | - |
| - 18822888888888888888888888888888888888 | 80.87.5648.810 | - |
| Cosine, 87992518798618795105 9793717 8795333 8799946 87989946 87989946 8789555 | 8788171 8785394 8785394 8781203 87781303 8774830 87770433 | Sine. |
| Cotang. 1-853325 1-852035 1-852035 1-848461 1-848461 1-846892 1-843049 | 5130 4771588 542955 1-841770 8788171 30 5031 4774144 54332 1-844494 8786783 19 5031 4774144 54332 1-844494 87865394 28 533 4777925 544086 1-833924 8784539 28 534 4781810 544086 1-833921 878492 28 536 4784364 544840 1-833189 8778930 28 538 4789265 545978 1-83189 8777043 28 538 4792026 545972 1-83189 8777043 28 539 4794579 546350 1-830327 8776649 21 540 4797131 546728 1-829652 8774254 20 | Tang. |
| Tang. 539570 540322 540598 541074 541450 642202 542579 | 542955 543332 543332 54463 54463 545217 545595 5465359 546728 | Cotang. |
| Sine. Tang. (21 4748564 539570 22 4751124 539946 23 4753683 540322 24 4756242 540598 25 4758901 541074 25 47653917 541826 28 4766474 542529 28 4769031 542579 28 4769031 542579 | 30 4771588 542955 131 4774144 54332 132 4776154 564332 133 4779255 5644630 134 4784364 564840 135 4784364 5645972 138 47782026 5645972 138 47794579 546550 140 4797131 546728 1 | ' Cosine. Cotang. Tang. |
| Sin 24758 4758 28 4758 28 4758 28 4768 28 4768 28 4768 28 4768 28 4768 28 4768 28 4768 | - 0.00 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | 4 |
| 500000000000000000000000000000000000000 | 10082799979 | |
| Cotang. Cosine. 'Sine. Tang. 189726 8829478 6021 4748564 539570 1878089 8829478 6021 4748564 539946 1878089 8826743 5823 4753683 540322 187873 8825376 5724 4756242 540598 187528 8825376 5724 4756242 540598 187528 882126 5459 4765914 541826 187523 882126 54274 56474 542229 187523 8818527 5229 4769031 542579 1 | \$68906 \text{-8817155} 51 30 \text{-4771588} \text{-542955} 1877400 \text{-8817600} \text{-8813779} 1887600 \text{-8814709} 1833 \text{-4774144} \text{-543332} 1864992 \text{-8813035} 1883 \text{-4770255} 544086 186390 \text{-8813035} 1883 \text{-4784364} 544463 186590 \text{-8808907} 4536 \text{-4786919} 5465217 185379 1880479 \text{-8807550} 4438 \text{-4786919} 5465217 185390 \text{-8808166} 1838 \text{-4786919} 5465217 185390 \text{-8808166} 140 \text{-4797131} 546728 1854615 \text{-8802014} 40 | Sine. |
| Cotang. 1-880726 1-879407 1-87673 1-87673 1-87673 1-87673 1-87673 1-87145 1-871523 | 1.868906 .8817155 1.867260 .8815782 1.866295 .88114409 1.863690 .8813036 1.86389 .8812036 1.86389 .8810284 1.858496 .8806152 1.858496 .880474 1.858496 .880474 1.858416 .880474 | Tang. |
| Sine. Tang. 694716 -531709 697284 -532082 702419 -532829 704986 -533202 701019 -533950 710155 -534324 712685 -534324 715250 -534698 | .635072 .535846 .536820 .536820 .53630 .537319 .637694 .538069 .638819 .638819 | Cotung. Tang. |
| Sine, Tang. Cotang. Cosine. '4694716 531709 1.880726 8829476 60 4697284 532082 1.879407 8828110 59 47092419 532829 1.875458 8824007 56 470956 533576 1.874445 8822638 55 471019 53360 1.875423 88219898 53 4712685 534324 1.871523 8819898 53 4715256 534324 1.871523 8818527 52 | 9-4717815 5-535072 1-868906 -8817155 5130 -4771588 -542955 1-841770 -8788171 10-4720380 -535446 1-867600 -8815782 5031 -4772044 -54332 1-844494 -8786783 112-472294 -535520 1-862295 -8813409 4932 -4775700 -543709 1-839218 -8785394 112-472509 -535520 1-862295 -8813409 4932 -4775700 -543709 1-839218 -8785394 113-472509 -535520 1-862389 -8813403 4781810 -544463 1-835671 -8782613 114-4730634 -536594 1-862389 -8810284 46.35 -4786919 -545271 -831129 -8779830 16-4733759 -537694 1-852389 -8810284 46.35 -4786919 -545251 1-831129 -8779830 16-4733759 -537694 1-852399 -8807530 44.37 -4780472 -545595 1-83369 -8778439 1774043 -538069 1-855496 -8806152 -4338 -4794579 -546350 1-833037 -8775649 19-4743604 -539195 1-8554615 -88022014 4140 -4797131 -546728 1-8289662 -8774254 10-4746004 -539195 1-8554615 -88022014 4140 -4797131 -546728 1-8289662 -8774254 10-4746004 -539195 1-8554615 -88022014 4140 -4797131 -546728 1-8289662 -8774254 10-4746004 -539195 1-8554615 -88022014 4140 -4797131 -546728 1-8289662 -8774254 10-4746004 -539195 1-8554615 -88022014 4140 -4797131 -546728 1-8289662 -8774254 10-4746004 -539195 1-8554615 -88022014 4140 -4797131 -546728 1-8289662 -8774254 10-4746004 -539195 1-8554615 -88022014 4140 -4797131 -546728 1-8289662 -8774254 10-4746004 -539195 1-8554615 -88022014 4140 -4797131 -546728 1-8289662 -8774254 10-4746004 -539195 1-8554615 -88022014 4140 -4797131 -546728 1-8289662 -8774254 10-4746004 -539195 1-854615 -88022014 4140 -4797131 -546728 1-828962 -8774254 10-4746004 -539195 1-854615 -88022014 4140 -4797131 -546728 1-828962 -8774254 10-4746004 -539195 1-854615 -88022014 4140 -4797131 -546728 1-828962 -8774254 10-4746004 -539195 1-854615 -8802391 -4746004 -539195 1-854615 -8802391 -4746004 -539195 1-854615 -8802391 -4746004 -539195 1-854615 -8802391 -4746004 -539195 1-854615 -8802391 -4746004 -539195 1-854615 -8802391 -4746004 -539195 1-854615 -8802391 -4746004 -539195 1-854615 -8802391 -4746004 -539195 1-854615 -8802391 -4746004 -539195 1-854615 -8802391 -4746004 -539195 1-854615 -8802391 -4746004 -539195 1- | Cosine. |
| - 0-000-00-0 | 00-00-00-00-00 | 3 |

Deg. 61.

| 89 Deg. Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cotang. Cosine. Sine. Tang. Cotang. Cotang. Cosine. Sine. Tang. Cotang. Tang. Cotang. Cotang. Cotang. Cotang. Tang. Cotang. Cotang. Tang. | | | | 100 | A. | 81 | Me | |)F | 2 | 11 | E | s, | 1 | A | Ne | ĖE | N. | 18 | , | EI | C. | | | | 10 |
|--|------------------|---------|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|---------|-------|
| 8 Deg. Sine. Tang. Cotang. Cosine. Sine. Tang. Sine. Tang. Sine. Sin | | - | 15 | 2 | 18 | 17 | 16 | 15 | 14 | 13 | 55 | Ξ | 10 | 6 | 80 | 7 | 9 | 5 | 4 | 3 | C.5 | - | 0 | | 1- | 1 |
| 9 Deg. 29 Deg. Cotang. Cotang. <th< td=""><th></th><td>Cosine.</td><td>00000000</td><td>0011999</td><td>8686315</td><td>8684874</td><td>8683431</td><td>8681988</td><td>8680544</td><td>8679100</td><td>8677655</td><td>8676209</td><td>8674762</td><td>8673314</td><td>8671866</td><td>8670417</td><td>7968998</td><td>8667517</td><td>8666066</td><td>8664614</td><td>8663161</td><td>8661708</td><td>8660254</td><td></td><td>Sine.</td><td>Dag 6</td></th<> | | Cosine. | 00000000 | 0011999 | 8686315 | 8684874 | 8683431 | 8681988 | 8680544 | 8679100 | 8677655 | 8676209 | 8674762 | 8673314 | 8671866 | 8670417 | 7968998 | 8667517 | 8666066 | 8664614 | 8663161 | 8661708 | 8660254 | | Sine. | Dag 6 |
| 9 Deg. 29 Deg. Tang. Cotang. C | - | Cotang. | 1.754979 | 210401.1 | 1-753186 | 1-752002 | 618091-1 | 1-749637 | 1-748456 | 1-747276 | 1-746098 | 1-744921 | 1-743745 | 1-742570 | 1.741396 | 1-740224 | 1-739053 | 1.737883 | 1.736714 | 1-735546 | 1-734380 | 1-733214 | 1-732050 | | Tang. | |
| 9 Deg. 29 Deg. 20 Deg. <th< td=""><th>The same</th><td></td><td>157000A</td><td>+000/c</td><td>688016</td><td>-570775</td><td>-571161</td><td>-571547</td><td>-571933</td><td>-572319</td><td>-572705</td><td>-573091</td><td>-573478</td><td>-573864</td><td>574251</td><td>574638</td><td>-575025</td><td>.575412</td><td>-575799</td><td>576187</td><td>-576574</td><td>-576962</td><td>-577350</td><td></td><td>Cotang.</td><td></td></th<> | The same | | 157000A | +000/c | 688016 | -570775 | -571161 | -571547 | -571933 | -572319 | -572705 | -573091 | -573478 | -573864 | 574251 | 574638 | -575025 | .575412 | -575799 | 576187 | -576574 | -576962 | -577350 | | Cotang. | |
| 29 Deg. Sine. Tang. Cotang. Cosine. Sine. | Deg. | Sine. | 4050000 | 000700 | 4954587 | 4957113 | 4959639 | 4962165 | 4964690 | 4967215 | 4969740 | 4972264 | 4974787 | 4977310 | 4979833 | 4982355 | 4984877 | 4987399 | -4989920 | 4992441 | 4994961 | 4997481 | .5000000 | | Cosine. | |
| 8 Deg. | 29 | - | 1 ; | 1 4 | 7.7 | 13 | 44 | 45 | 16 | 17 | 8 | 61 | 00 | 51 | 55 | 53 | 54 | 55 | 99 | 57 | 58 | 69 | 09 | | 1- | |
| 9 Deg. | 7 | - | 100 | 2 0 | 38 | 37 | 3 36 | 135 | 34 | 33 | 35 | 31 | 130 | 29 | 88 | 27 | 26 | 35 | 24 | 23 | 25 | 21 | 320 | | 1 | 80 |
| 9 Deg. Tang. Cotang. Cosine. Sine. Trang. Cotang. Sine. Trang. Cotang. Trang. Cotang. Trang. Cotang. Trang. Cotang. Sine. Trang. Cotang. Trang. Cotang. Trang. Cotang. Trang. Sine. Trang. Cotang. Trang. Sine. Trang. Cotang. Trang. Sine. Trang. Sine. Trang. Sine. Trang. Sine. Trang. Sine. Trang. Cotang. Trang. Sine. Trang. Sine. Trang. Trang. Sine. Trang. Trang. Sine. Trang. Trang. Sine. Trang. Trang. Sine. Trang. Trang. Trang. Sine. Trang. Trang. Sine. Trang. Trang. Sine. Tr | | Cosine. | 2172170 | 2150110 | 8714995 | 8713566 | 8712138 | 8710710 | 8709281 | 8707851 | 8706420 | 8704989 | 8703557 | 8702124 | 8700691 | 8699256 | 8697821 | 8696386 | 8694949 | 8693512 | 8692074 | 8690638 | 8689196 | | Sine. | Dan |
| 8 Deg. Tang. Cotang. Cosine. Sine. Tang. Cosine. Sine. Tang. Cotang. Cosine. Sine. Tang. Cosine. Cotang. Cosine. Sine. Tang. Cosine. Cotang. Cosine. Sine. Tang. Cosine. Cotang. Cosine. Cotang. Cosine. Cotang. Cosine. Cotang. Cosine. Cotang. Cosine. Cosine. Cosine. Cotang. Tang. Sine. S | No. of Lot, Lot, | Cotang. | 01,0077.1 | 04.0011. | 1-777130 | 1-775921 | 1.774714 | 1.773507 | 1-772302 | 1-771098 | 1-769895 | 1.768694 | 1-767494 | 1-766295 | 1-765097 | 1-763900 | 1-762705 | 1.761511 | 1.760318 | 1.759126 | 1-757936 | 1-756747 | 1-755559 | | Tang. | - |
| 8 Deg. Tang. Cotang. Cosine. Sine. Sine. Sine. Cotang. Cosine. Sine. Sine. State | 1 | Tang. | 1666937 | 120200 | £0229c | -563087 | 563471 | -563854 | -564237 | -564621 | -565005 | -565388 | -565772 | 991999 | -566541 | -566995 | -567309 | -567694 | -568079 | -568463 | 568848 | .569233 | .569619 | | Cotang. | |
| 9 Deg. Sine. Tang. Cotang. Cosine. | Deg. | Sine. | 4001499 | 0041004 | 4903968 | 4906503 | 4909038 | 4911572 | 4914105 | 4916638 | 4919171 | 4921704 | 4924236 | 4926767 | 4929298 | 4931829 | 4934359 | 4936889 | 4939419 | 4941948 | 4944476 | 4947005 | 4949532 | | | |
| Sine. Tang. Cotang. Cosine. | 53 | - | 1 6 | 100 | 24 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 35 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | | 1 | 1 |
| Sine. Tang. Cotang. Cosine. | | - | 100 | 00 | SC | 58 | 57 | 56 | 55 | 54 | 53 | 52 | 51 | 50 | 49 | 48 | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 40 | 1- | 1 |
| Sine. Tang. Cotang. Sine. Tang. Cotang. 4826040 554430 1-804047 48355727 555450 1-804047 48855727 555450 1-804047 48855727 555451 1-797875 48853354 5556521 1-797875 48853554 5556521 1-797875 48868436 557355 1-794188 94870977 555499 1-796418 94870977 555499 1-795416 94886351 558499 1-789289 14888750 560409 1-789289 15888750 560409 1-789528 15888750 560409 1-789558 15888750 560409 1-789558 15888750 560409 1-789558 15888750 560409 1-789558 15888750 560409 1-789558 15888750 560409 1-78958 15888750 560409 1-78958 15888750 560409 1-78958 158888750 560409 1-78958 158888750 560409 1-78958 158888750 560409 1-78958 158888750 560409 1-78958 158888750 560409 1-78958 158888750 560409 1-78958 158888750 560409 1-78958 158888750 1-78958 158888750 1-78958 1588888750 1-78958 158888750 1-78958 158888750 1-78958 158888750 1-78958 158888750 1-78958 158888750 1-78958 158888750 1-78958 158888750 1-78958 158888750 1-78958 158888750 1-78958 158888750 1-78958 158888750 1-78958 158888750 1-78958 158888750 | - | Cosine. | 7013170 | 1610410 | 8744786 | 8743375 | 8741963 | 8740550 | 8739137 | 8737722 | 8736307 | 8734891 | 8733475 | 8732058 | 8730640 | 8729221 | 8727801 | 8726381 | 8724960 | 8723538 | 8722116 | 8720693 | 8719269 | 8717844 | | Dow 6 |
| 8 Deg. Tang. 6 Sine. Tang. 6 4848096 554809 6 4855184 5550689 6 4855727 555450 6 4855727 555450 6 4855727 5556973 6 6 4868436 557355 6 6 4868436 557355 6 6 4868436 557356 6 6 4888750 560409 6 4888750 560409 6 4888750 560409 6 4898887 561173 6 6 4898887 561173 6 6 4898887 561173 6 6 4898887 561173 6 6 4898887 561173 6 6 4898887 561173 6 6 4898887 561173 6 6 4898887 561173 6 6 4898887 561173 6 6 4898887 561173 6 6 4898887 561173 6 6 4898887 561173 6 6 6 4898887 561173 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 | - | Cotang. | 1.004047 | 140400.1 | 018208-1 | 1-801575 | 1.800340 | 1-799107 | 1-797875 | 1-796645 | 1-795416 | 1.794188 | 196264-1 | 1-791736 | 1-790512 | 1-789289 | 1-788067 | 1-786847 | 1-785628 | 1-784410 | 1-783194 | 1-781979 | 1-780765 | 1-779552 | Tang. | |
| 8 Deg. Sine. 9 4848096 9 4848096 9 4855727 4 4858270 5 4868812 6 4868436 9 4870977 11 4876597 12 4878597 13 4881136 14 4888750 17 4891288 18 4893825 10 4893825 10 4893825 10 4893825 10 4893825 10 4893825 10 4893825 10 4893825 10 4893825 10 4893825 10 4893825 10 4893825 10 4893825 | - | Tang. | 254000 | 600400 | .554689 | -555069 | 555450 | -555831 | -556211 | -556592 | .556973 | -557355 | -557736 | 558117 | 558499 | 188899 | 559262 | -559644 | -560026 | 560409 | -560791 | -561173 | -561556 | -561939 | Cotang. | |
| 0 - 0 - 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | Jeg. | | 404000 | 000000 | 4850640 | 4853184 | 4855727 | 4858270 | 4860812 | 4863354 | 4865895 | 4868436 | 4870977 | 4873517 | 4876057 | 4878597 | 4881136 | 4883674 | 4886212 | 4888750 | 4891288 | 4893825 | 4896361 | 4898897 | Cosine. | |
| | 16 | | 19 | | - | CS | | 4 | | 9 | 7 | 00 | 6 | 01 | 11 | 57 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 50 | 1. | |

NATURAL SINES AND TANGENTS TO A RADIUS 1.

| | | | | | | | | | | | | | | _ | | | | | _ | | _ | _ | - | - |
|---------|---------------------------|---|--|--|---|--|---|---|--|--|---|---|---|---|---|--|---|---|--|--|--|--|-----------------|----------|
| 1 | 1 | 19 | - | 17 | 91 | 15 | 7 | - | : | 19 | 10 | 200 | 0 | 1 | 9 | 2 | 4 | 3 | 25 | - | 0_ | | - | . 59 |
| 1 | Cosine. | 8600007 | 8598523 | 8597037 | 8595551 | 8594064 | 8592576 | 8201088 | 8589599 | 6018868 | \$1000CS. | 1210808. | 8583635 | 8582143 | 8580649 | 8579155 | 8577660 | 8576164 | 8574668 | 8573171 | 8571673 | | Sine. | Dog. 59. |
| - | Cotang. | 1-685308 | 1.684191 | 940889-1 | 1-681962 | 1-680848 | 1-679736 | 1-678625 | 1.677515 | 1.676406 | 967919.1 | 1.674192 | 1-673086 | 1.671981 | 878078-1 | 1-669775 | 1.668674 | 1-667574 | 1.666474 | 1-665376 | 1-664279 | 1 | I hang. | |
| | Tang. | -593363 | -593756 | -594150 | -594543 | -594937 | -595331 | -595725 | -596119 | -596514 | 206966 | -597303 | -597697 | -598092 | -598487 | -598882 | -599278 | 599673 | 690009- | -600464 | 098009- | | Cotang. | |
| 30 Dec. | Sine. | 5102928 | 5105429 | 5107930 | 5110431 | 5112931 | 5115431 | 5117930 | 5120429 | 5122927 | 5125425 | 5127923 | 5130420 | 5132916 | 5135413 | 5137908 | 5140404 | 5142899 | 5145393 | 5147887 | 5150381 | | Cosine. Cotang. | - |
| 30 | ,,, | 941 | 842 | 743 | 641 | 545 | 446 | 347 | 248 | 149 | 020 | 951 | 8 52 | 7 53 | 654 | 555 | 4 56 | 357 | 2 58 | 1 59 | 090 | | 111 | 9 |
| | Cosine. | 8629549 3 | 8628079 | 8626608 | 8625137 3 | 8623664 3 | 8622191 3 | 86207173 | 8619243 3 | 8911198 | 8616292 3 | 8614815 2 | 8613337 2 | 8611859 2 | 5085406 :590613 1-693155 -8610380 2654 -5135413 -598487 1-670878 -8580649 | 8608901 2 | 8607420 2 | 8605939 2 | 8604457 2 | 8602975 2 | 8601491 2 | | Sine. | Deg. 59 |
| | Tang. Cotang. Cosine. | 1.707871 | 1-706732 | 1-705595 | 1.704458 | 1.703323 | 1.702189 | 1.701055 | 1-699923 | 1-698792 | 1.697663 | 1-696534 | 1.695406 | 1.694280 | 1.693155 | 1.692030 | . 206069-1 | 1.689785 | 1.688664 | 1-6875441 | 1.686426 | | Tang. | |
| | Tang. | 585524 | 585914 | 586305 | 586696 | 587087 | 587478 | 587870 | 588261 | 588653 | 588042 | 589436 | 589828 | 590221 | 590613 | 591005 | 501398 | 102109 | 592183 | 592576 | -592969 | | Cotang. | |
| 30 Deg. | Sine. | 5059809 | -5055319 | -5057828 | 5060338 | -5062846 | -5065355 | 5067863 | -5070370 | 5072877 | -5075384 | 5077890 | -5080396 | 1062809 | 5085406 | 5087910 | 5000414 | 5090918 | 5095491 | 5097924 | -5100426 | | Cosine. Cotang. | |
| 30 | - | 15 | 22 | 53 | 24 | 25 | 26 | 27 | 28 | 53 | 30 | 31 | 32 | 33 | 3.4 | 1 10 | 36 | 27.0 | 800 | 39 | 40 | | - | 1 |
| | Cosine. | 2000007 - 2000007 - 2000007 - 2000007 - 2000007 - 2000007 - 2000007 - 2000007 - 2000007 - 2000007 - 2000007 - 2000007 - 200000007 - 20000007 - 20000007 - 20000007 - 20000007 - 20000007 - 20000007 - 20000007 - 20000007 - 20000007 - 20000007 - 20000007 - 20000007 - 20000007 - 20000007 - 200000007 - 200000007 - 200000007 - 200000007 - 200000007 - 200000007 - 200000007 - 200000007 - 200000007 - 200000007 - 200000007 - 2000000007 - 2000000007 - 20000000000 | 2000000 57730 (173200 500000 500000 500000 | . 2002-201-201-201-201-201-201-201-201-201 | 1300000 1300000 1 1 1 1 1 1 1 1 1 1 1 1 | $\begin{array}{cccccccccccccccccccccccccccccccccccc$ | $\frac{30}{10000000000000000000000000000000000$ | 901:2031 - 101:2031 - | $\begin{array}{c} -0.17624.5810681.722934.8650055.5328.5070370.588261.1699923.8619243.3248.5120429.596119.1.677515.8589599.99810.167715.16716.1$ | 5020140-5804571-722779-8648595 5229-5072877-5886531-698792-86177683149-5522927-5965141-67640-8588109 | 9.5022655.580846 1.721626 -8647134 5130 -5075384 -589045 1.697663 -8616292 3050 -5125425 -596908 1.5075384 -589045 1.697663 | 0.50-517.5812351720473-86456735031-5077890-5894361-696534-8614815 2951-5127923-5973031-674192-5953121 | 2000100 101 101 1020 1020 1020 1020 102 | 11.002/005/005/005/005/005/005/005/005/005/ | DEA 1994 A7 | 3.503213.5324441.11/045.041.12455.5027110.591.005 6692030.8608901.2555.5137908.598882 1.669775 8579155 | 4-5035227-582793 1715973 50555574 505550741 505557660 | 5.503/740.583.821.114.725.05555555555555555555555555555555555 | 6.5044232.785372 1.153524 20000059 1.056421 1.59542 1.056421 1.0564 | 77 3042 (b) 35802 7.12503 (c) 350526 4.239 (c) 3505276 7.687544 (c) 3602975 21 39 5147887 (c) 0464 1.665376 (c) 573171 | $\begin{array}{cccccccccccccccccccccccccccccccccccc$ | 20 -5050298 -585133 1-709011 -8631019 40 | Sine. | Dog. 59. |
| | Cotang, Cosine. | 1.700050 | 1.790887 | 1.790796 | 1.799565 | 1.797406 | - 756947 | 1.795090 | 1-723934 | 1-722779 | 1-721626 | 1.720473 | 1.710399 | 1.01710171 | 1.712000 | 1.715075 | 0/901/.1 | 1.714728 | 1.7193982 | 1.711904 | 1.710152 | 1.709011 | Tang. | |
| | Tang. | CHOWNE | 006110 | 2010/2 | 001010. | #10010. | 570501 | 252616 | 580068 | -580457 | 580846 | 581935 | 501694 | 01000 | 010280. | E04526. | 26/280 | 281886 | 27083072 | 208580 | 584743 | 585133 | Cotang. | 0 |
| Jeg. | Je. | 0000000 | 00000000 | 5005000 | 2000000 | 0001000 | 201020102 | 1802:00 | 5017624 | 5020140 | 5022655 | 5095170 | 2022605 | 2001200 | 5030199 | 5032713 | 222509- | 5037740 | 5040252 | 50455765 | 5047788 | 5050298 | Cosine, Cotang. | - |
| 30 Deg. | - | 19 | 0 - | + C | 4 5 | 2 - | 4 1 | 3 0 | 0 1 | - 00 | 0 | | 1 1 | 111 | 7 . | 13 | 14 | 15 | 16 | 7 | 10 | 20 | 1 | 1 |

| Sine. Tang. Cotang. | | | TABLE OF BEREE, THE GENERAL STATE | | |
|--|------|---------|---|---------|----------|
| Sincere Cotang. Cota | 1 | -1 | 0.87.95488100.007.0048810 | - | 58. |
| Sine Tang Cotang Cotang Sine Tang Cotang Cotang Cotang Cotang Cotang Cotang Sine Tang Cotang Cotang Sine Tang Cotang Cotang Sine Tang Cotang Sine Tang Cotang Sine Tang Cotang Sine Tang | | Cosine. | 8509639 85050811 8505053 8503522 8501991 8501991 8497394 8497394 8497394 8497394 8497739 8497739 849777 8488179 8488179 8488102 8483562 8483562 8483562 | Sine. | Deg. |
| Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. | 1 | Cotang. | 1-620192 1-619138 1-615982 1-615982 1-615982 1-612834 1-611787 1-610741 1-609696 1-609665 1-60966 1-609 | | |
| Sine. Sine. Sine. Cotang. Cosine. Sine. Tang. Cotang. Cosine. Sine. Sine | | Tang. | 617210 617612 618416 618416 61921 620628 620832 620832 620832 620832 620832 622845 6228445 6228445 6228445 62284465 62284465 6228466 62286 622866 62286 62286 62286 6286 6286 6286 6286 6286 6286 6286 6286 6286 6286 6286 6286 6286 62 | Cotang. | |
| Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. Sine. Sine. Tang. Cotang. Cosine. Sine. Sine | Deg. | Sine. | 5252241 5224717 52257191 52557191 52567195 52667185 52667185 52697185 5274502 5274779 5274779 5274779 5274779 5274779 | Cosine. | |
| Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. Sine. Sine. Tang. Cotang. Cosine. Sine. Sine. Cotang. Cosine. Sine. Sine. Sine. Cotang. Cosine. Sine. Sine. Sine. Sine. Sine. Cotang. Cosine. Sine. Sine | 31 | , , | 8842 7743 7743 7743 7743 7743 7743 7743 7743 7743 775 775 777 777 777 777 777 77 | 1 | œ. |
| Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Sine. Sine. Tang. Cotang. Sine. Sine. Tang. Cotang. Sine. Sine. Tang. Cotang. Sine. Sine. Tang. Cotang. Second Secon | | Cosine. | 85340051 8538538 8533508 8533508 8533992 8532475 8523475 8523406 8523406 8523406 8523402 85243360 85243360 85243360 85134219 85134219 8511167 851269 | | Deg. 5 |
| Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. | | Cotang. | 1641482 1640408 16382633 1638263 16386121 163884 1638912 163894 162972 1628972 | | |
| Sine. Tang. Cotang. Cosine. Sine. Sine. 65150381 65150381 600860 6160382 600860 660383 600860 660384 660385 660385 660386 660 | | Tang. | 609205 609604 601003 6101001 611201 612801 613201 613201 613400 613202 614403 615204 615204 616809 | Cotang. | |
| Sine. Tang. Cotang. Cosine. / / / / Sine. Totalg. Cotang. Cosine. / / / / / / / / / / / / / / / / / / / | Deg. | Sine. | 5202646 5205130 5210096 5212579 5212579 5222756 5222945 5222945 5223945 5223945 5223945 5223945 5223945 5223945 5223945 5223945 | Cosine | |
| Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. 51552874 601256 1664279 8571673 51552874 601256 1663183 857175 51552874 601256 1663183 857175 5155287 60249 1669994 85687175 5162542 602241 1658809 85687175 5162542 602241 1658809 85687175 5162542 603281 165482 856871 517204 604429 1654452 8556655 517204 604429 1654452 8556655 517204 60429 165280 8556149 5175293 604826 165280 8556149 5175293 604826 165280 8556149 5180270 606521 165119 8553643 5180279 606814 1647949 8549119 65190219 607213 164686 8547099 751802706 60417 1649030 85640199 751802706 604471 1643030 8544588 751802706 608408 1643633 8544588 751802706 608408 1643633 8544588 7518027076 608408 1643633 8544588 7518027076 608408 1643633 8544588 7518027076 608408 1643633 8544588 7518027076 608408 1643633 8544588 7518027076 608408 1643633 8544588 7518027076 608408 1643633 8544588 7518027076 608408 1643633 8544588 7518027076 608408 1643633 8544588 7518027076 608408 1643633 8544588 7518027076 608408 1643633 8544588 7518027076 608408 1643633 8544588 7518027076 608408 1643633 8544588 7518027076 608408 1643633 8543077 7518027076 608408 1643633 8544588 7518027076 608408 1643637 8541564 7518027076 608408 1643637 8541564 7518027076 608408 1643637 8541564 7518027076 608408 1643637 8541564 7518027076 608408 1643637 8541564 751802708 608408 1643637 8541564 751802708 608408 1643637 8541564 751802708 608408 1643637 8541564 751802708 608408 1643637 8541564 751802708 608408 1643638 8541564 751802708 608408 1643638 8541564 751802708 608408 1643638 8541564 751802708 608408 1643638 8541564 751802708 608408 1643638 8541564 751802708 608408 1643638 8541564 751802708 608408 1643638 8541 | 31 | 1,1, | 0.0 8 7 8 8 8 8 7 8 8 8 8 8 8 8 8 8 8 8 8 | 1- | à |
| Sine. Tang. Cotang. 5.515.2874 -601256 1-664279 1-515.2874 -601256 1-663183 2-515.285 -602049 1-60994 4-516.381 -602045 1-65990 6-516.283 -602049 1-65990 6-516.283 -602049 1-65990 6-516.283 -602049 1-65990 6-516.283 -602049 1-65990 6-516.283 -602049 1-65990 8-5170314 -604029 1-655540 9-517829 -60429 1-651296 11-517782 -605224 1-65230 11-517782 -605224 1-65249 11-5182738 -606019 1-651196 11-5182738 -606019 1-651196 11-5182738 -606019 1-651196 11-5182738 -606019 1-647949 11-5182738 -606019 1-647949 11-5192705 -607213 1-46868 17-5192705 -607213 1-46868 17-519519 -608009 1-644711 19-519519 -608009 1-644511 19-5197676 -608408 1-642557 1 | | Cosine. | 8571673 8558675 8558674 85568674 85562674 85562674 8556168 8556168 8555169 8555149 8555149 8555149 8554199 8554199 8544588 8544588 | i | Deg. 58. |
| Sine. Tang. Sine. Tang. | | Cotang. | 1.664279 1.663183 1.662088 1.6620894 1.655718 1.655540 1.655540 1.653366 1.653366 1.653366 1.651196 1.651196 1.647949 1.647949 1.64711 1.643633 1.643633 | | |
| Sine. Sine. 5150381 1.5152874 2.5155867 3.5157859 3.5157859 3.5157824 3.5172804 10.5175293 11.5177782 11.5177782 11.5177782 11.5177782 11.5177782 11.5177783 11.518246 12.5180270 11.5177783 11.518246 12.5180270 11.518246 12.5180270 11.518240 11.5 | | Tang. | 600866 601266 602049 602049 602445 603238 603635 604632 604826 605621 6066119 6066119 6066119 606119 | Cotano | 9 |
| 1 10108846978661 | leg. | Sine. | 5150381 5152874 51552874 51652874 5160351 5160351 5167314 5170314 5175293 5177782 5180270 5182758 5180270 5182705 5187705 5187738 5187705 518705 51870 | | |
| | 31 I | - | 01284687000113846600 | 1- | - |

| 0 | | TABLE OF SINES, TANGENTS, ETC. | |
|----------|-------------------|---|---------------------------|
| | - | 0.00 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | - |
| | Cosine. | 0.5229193 6224869 1-636089 1-638099 1-6301659 6241577 1-539169 1-539169 1-558657 1-541669 1-559669 8441899 1-5501659 8441899 1-5501659 8441899 1-55668 8441899 1-55668 8441899 1-55668 8441899 1-55668 8441899 1-55668 8441899 1-55668 8441899 1-55668 8441899 1-55668 8441899 1-55668 8441899 1-55668 8441899 1-55668 8441899 1-55668 8441899 1-55668 8441899 1-55668 8441899 1-55668 8441899 1-55668 841189 1-55669 841089 1-55689 841889 1-55689 1-55689 841889 1-55689 841889 1-55689 841889 1-55689 841889 1-55689 841888 1-55689 841888 1-55689 841888 1-55689 841888 1-55689 841888 1-55689 841888 1-55689 841888 1-55689 841888 1-55689 841888 1-55689 841888 | Sine. |
| | Tang. Cotang. | 1.558657 1.557660 1.556683 1.554674 1.553680 1.553680 1.553680 1.553680 1.548726 1.548726 1.54873 1.54873 1.544779 1.543794 1.543794 1.543794 1.543794 1.543794 1.543794 1.543898 | Tang. |
| | Tang. | -641577 -641988 -642399 -6432810 -643632 -64456 -64456 -64456 -64456 -64456 -64456 -64456 -64456 -646104 -646516 -6463 | Cotang. |
| 32 Deg. | Sine. | 55399955 5407483 5407488 5410748 541179 5411463 542191 54219 5 | / Cosine. |
| 33 | - | 44444444444444444444444444444444444444 | - |
| | - | 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 | - |
| - | Cosine, | 844432 844432 844432 844417 84432 844107 843354 843354 843354 843354 843354 843354 842452 842452 842452 842452 842452 842452 842452 842452 842452 | Sine. |
| | Tang. Cotang. | 1 - 5399133 624869 1600034 6418948 60 21 5350898 6533355 167776 6446395 3842 5402403 641988 1557660 6415108 25034155 625673 1599299 6418999 6418399 6413586 6415108 641928 6419 | Tang. |
| | Tang. | 633395 633803 634211 634619 635027 635545 635844 637070 6377479 6377888 638107 63910 639526 639936 641167 | Cotang. |
| 3.2 Deg. | Sine. | 6350898 6353355 6353356 6358268 6360734 636634 6376634 6377902 6377902 638635 6387708 638636 6387708 638636 6387708 638636 | / / Cosine. Cotang. Tang. |
| 32 | _ | 1 2 2 2 3 2 3 2 3 2 3 2 3 2 3 2 3 2 3 2 | - |
| | - | 60 50 50 50 50 50 50 50 50 50 50 50 50 50 | ` |
| | Cotang. Cosine. | 948048 947589 947789 947789 947789 947780 946672 946672 946672 946672 946572 946572 945880 | Sine. |
| | | 1-600034 1-599299 1-599299 1-599198 1-599198 1-599107 1-599107 1-5990029 1-588997 1-588997 1-588997 1-583883 1-58388 1-5838 1-5838 1-5838 1-58388 1-58388 1-58388 1-5838 1-5838 1-58388 1-58388 | Tang. |
| | Tang. | 624869 625273 625273 625683 625683 627298 627704 627704 629327 629327 62973 62 | Cotang. |
| 32 Deg. | Sine, | 1-5301659 -625273 1-599299 -8478939 59 2-5305125 -625678 1-599299 -8478939 59 3-5305611 -256083 1-59721 -847589 758 4-5309057 -626488 1-59721 -8472765 55 5-531521 -626893 1-595167 -8472765 55 6-5313986 -627298 1-59107 -846973 53 7-5318915 -628515 1-59107 -846973 53 8-5318915 -628515 1-59107 -846973 53 9-532376 -628515 1-59100 -8466599 10 5-532630 1-62932 1-592902 -8466830 45 12-532630 1-62932 1-58997 8463481 49 12-532630 1-62932 1-58997 8463481 49 12-53265 -63054 1-58992 8463830 45 13-533865 -63054 1-58992 8453778 45 14-533865 -63054 1-58992 8455728 45 15-5336 145 -63053 1-58849 -845778 84 15-5336 145 -63053 1-58849 -845778 84 17-534 1065 -63176 1-58982 8454774 43 18-533865 -63258 1-58882 8454774 43 19-534582 -63258 1-58882 8454774 43 19-534582 -63258 1-58087 8449508 40 | Cosine, Cotang. |
| 32 1 | - | 0 1 2 8 4 2 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | - |
| - | | | |

| 33 Deg. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. | | | IAI |)LIL | OF | DITA | Eas, | IAL | CIL | A TO | , 1 | 10 | | | 1 | 20 |
|--|------|---------|----------|----------|----------|----------|--------------------|----------|--------------------|----------|----------|----------|----------|----------|---------|------|
| 33 Deg. Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Sine. Cosine. Cos | | F | 19 | 17 | | | 111 | 6 8 | 7 9 | 5 | 4 00 | CS. | | | - | 50. |
| 83 Deg. Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Sine. Tang. Sine. Tang. Sine. Tang. | | Cosine. | ·8319541 | 8317927 | 8314696 | 8311463 | 8308226 | 8304987 | ·8301745 | 8298500 | 8295252 | 8293628 | 8290376 | | Sine. | Deg. |
| 83 Deg. 33 Deg. 7 Sine. 7 Jang. Cotang. Cotang. <t< td=""><td></td><td></td><td>1.500382</td><td>1-498492</td><td>1.496605</td><td>1.494722</td><td>1.492842</td><td>1-490965</td><td>1.489092</td><td>1.487222</td><td>1.485355</td><td>1-484423</td><td>1.483491</td><td></td><td></td><td></td></t<> | | | 1.500382 | 1-498492 | 1.496605 | 1.494722 | 1.492842 | 1-490965 | 1.489092 | 1.487222 | 1.485355 | 1-484423 | 1.483491 | | | |
| ### Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. Sine. | Tang. | -666496 | 667337 | 668178 | -669020 | -669863 | -670706 | 671550 | 672394 | 673239 | .673662 | -674508 | | Cotang. | |
| 83 Deg. Tang. Cotang. | Deg. | Sine. | 5546024 | 5550864 | 5555702 | 5560539 | 5565373 | 5570206 | 5575036 | 5589979 | 5584692 | 5587105 | 5589517 | | Cosine. | |
| 83 Deg. Tang. Cotang. Cosine. Y Sine. Tang. Cotang. Cosine. Y 6446390 649407 1.539865 8386706 6021 -6446390 650231 1.519463 8353279 33 1.548830 649907 1.539884 8385121 592 -549950 658127 1.519463 8353279 33 2.5451269 6502351 1.53884 8383536 582 5502379 658477 35 5502379 658477 35 5502379 6584877 35 5502379 6584877 35 5502379 6584877 35 5502379 6584877 35 5504877 35 5504897 85 5504897 85 5504887 6504887 75 6685897 6504897 75 6685897 650689 75 650689 75 75 75 75 75 75 75 75 75 75 75 75 75 75 75 75 75 | 33 | - | 41 | 43 | 45 | 17 | 49 | 52 | 53 | 55 | 57 | 28 | 960 | 1 | - | |
| 83 Deg. Tang. Cotang. Cosine. Tang. Cotang. Cosine. 6-5446390 6494407 1-539865 838570 6021 5497520 658127 1-519463 835327 1 5448330 6499407 1-539865 8385381 5562379 658127 1-519463 835327 2 5451269 650649 1-538924 8381536 58.2 5562379 6583487 3 5453707 650649 1-538927 8381950 5724 5504807 1516579 83487 4 5456145 650649 1-538927 8381950 5724 5504807 659378 151650 834887 4 5456126 652306 1-538021 83877187 5425186 651661 151740 83406 8 546589 652306 1-532047 8377487 5425197 661880 153302 837589 5328 651467 1511790 83406 8 546589 653236 1-532047 837487 661886 1-51002 83406 9 | | | 988 | 0 37 | 7 35 | 2 33 | 3 31 | 2 29 | 8 27 | 25 25 | 2 23 | 1 22 | 0 21 | | - | 56. |
| 83 Deg. Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Sine. Sine. Tang. Cotang. Sine. Sine. Tang. Cotang. Sine. S | | Cosine | ·835327 | 835008 | 834527 | 834367 | 833885 | 833725 | ·833243 | 833082 | 832760 | 833599 | 832438 | | Sine. | Deg. |
| 83 Deg. 1 Tang. Cotang. Cosine. 1 Sine. Tang. 649407 1-539865 8386706 6021 54497520 6585127 1-548830 6499407 1-539865 8386706 6021 54497520 6585127 1-5448830 649921 1-539886 8323 5502379 658961 83-5458126 6562379 656964 1-532921 6322 5502379 658964 1-536127 636279 658964 1-536120 65891 1-53291 | | Cotang. | 1.519463 | 1.517540 | 1.515620 | 1-513703 | 1.511790 | 1.509880 | 1.507974 | 1.506071 | 1-504171 | 1.503222 | 1.502275 | | | |
| 83 Deg. Sine. Tang. Cotang. Cosine. Sine. 5446390 6499407 1-539865 -3386706 60 21 5499950 2-5446390 6499407 1-539865 -3386706 60 21 5499950 2-5451269 650235 1-539965 -3381950 5724 -5504807 4-5458145 6510631 -535949 -3381950 5724 -5504807 4-5458145 6510631 -535949 -3381950 5724 -5509683 5-545838 -6510631 -535949 -3381950 5724 -5509683 6-54611020 651831 -533921 -337589 6325 -551529991 7-5463156 652306 1-533921 -337589 6329 -5516944 9-5468328 653731 1-532047 -3372418 5130 -5519370 11-5473198 (553361 1-532102 -3372418 5131 -5521795 11-5473198 (553966 1-52119 -336928 49 32 -5524220 12-5475632 (554231 1-52221 -3364456 46 35 -5531192 13-548928 655212 1-52223 -336928 49 33 -5526645 14-5480499 (555212 1-52223 -336928 44 37 -553838 17-5480499 (555212 1-52223 -336928 44 37 -553838 16-545365 (556460 1-52232 -3358476 44 37 -553898 16-545365 (556977 1-52232 -3358476 44 37 -553898 18-549028 (556877 1-52232 -3358476 44 37 -553898 19-5492659 (557710 1-520426 -3354878 40 7 Cosine. Cotang. 1 ang. Sine. 1 Cosine. | | Tang. | 658127 | 659378 | -659796 | -660631 | ·661467 ·661885 | 662304 | ·663141 ·663560 | 663979 | -664817 | -665237 | -665657 | | Cotang. | |
| 83 Deg. Sine. Tang. Cotang. Cosine. 5446390 649407 1-539865 -8386706 60 21 5446390 6499407 1-539865 -8386706 60 21 5448330 649921 1-53984 -83851215922 2-5451269 650235 1-533949 -8389353 55 25 6-5410209 651891 1-539949 -8389363 55 25 6-5410209 651891 1-539949 -8378775 55 26 6-5410209 651891 1-539949 -8378775 55 26 6-548328 652721 1-532047 -837409 52 29 9-5468328 652721 1-532047 -837409 52 29 9-5468328 653136 1-531002 -8376848 48 33 11 -5473198 (553966 1-529130 -8366050 47 34 12 -5475632 654831 1-522160 -8366050 47 34 13 -548928 65528 1-522160 -8366050 47 34 14 -5480499 -65528 1-52221 -8364456 44 37 17 -5487797 -656460 1-522320 -8359670 43 38 18 -5490228 -656877 1-52235 -8358974 42 39 19 -5492659 657710 1-520426 -8354878 40 7 Cosine. Cotang. 1 ang. Sine. 1 7 | Deg. | Sine. | 5497520 | 5502379 | 5509663 | 5512091 | 5516944 | -5521795 | 55296645 | 5531492 | 5536338 | 5538760 | 5541182 | | Cosine. | |
| 83 Deg. Sine. Tang. Cotang. Cosine. 6446390 649407 1.539865 8386706 60 5446830 649821 1.538884 8385121 53 2.5451269 650235 1.538884 8385121 53 3.5453707 650649 1.536927 8381950 57 4.5456145 65 163 1.538949 8380383 56 6.5468388 65147 1634972 837875 55 6.54683156 652306 1.53899 8377187 54 7.5463156 652306 1.538021 837589 55 8.5468328 653230 1.538047 837244 8 51 10.54770763 653551 1.538047 837248 87 11.5473189 653966 1.528160 8367643 46 12.5475632 654381 1.528160 8367643 46 13.54806 654797 1.528160 8367643 46 14.5487797 655646 1.528169 8358864 45 15.5487797 655646 1.5283289 8358874 42 19.5492659 657710 1.528168 8358774 42 19.5492659 657710 1.528168 835877 42 7.568170 1.528168 8358874 42 19.5492659 657710 1.528168 8358874 42 19.5492659 657710 1.528426 8354878 40 7.56810c. Cotang. 1 ang. Sine. Deg. 56. | 33 | _ | 222 | 23 | 25 | 27 | 30 | 31 | 34 | 35 | 37 | 38 | 39 | | ` | |
| 83 Deg. Sine. Tang. Cotang. Cosine. | | - | 6 60 | 6 58 | 3 56 | 7 54 | 9 52 | 7 50 | 3 48 | 6 46 | 6 44 | 0 43 | 4 42 | 8 40 | - | 56. |
| 83 Deg. Sine. Tang. Cotang. 0.5446390 649407 1.539865 1.544830 649821 1.538884 2.5451269 650235 1.537905 3.5453707 650649 1.539885 5.5458583 651407 1.539867 7.5463156 652306 1.533921 8.54683156 652306 1.533921 10.5473198 653261 1.532130 12.5475632 655421 1.522130 12.5475632 655481 1.52130 12.5475632 655481 1.52130 12.5475632 655481 1.52130 13.547806 654797 1.52132 14.5480499 655321 1.522354 15.5482932 656688 1.522353 16.548293 656688 1.52235 17.5487797 656460 1.52332 18.5492659 657710 1.524286 17.5487797 656460 1.523320 18.5492659 657710 1.520324 18.5492659 657710 1.520324 | | Cosine | 838512 | 838353 | 838036 | 837718 | ·837400 | 837082 | 836764 | 836445 | 836126 | 835967 | 835807 | 835487 | | Deg. |
| 83 Deg. Tang. Sine. Tang. 5446390 649407 544830 649821 545830 649821 545830 649821 5458388 651477 6 5461020 6558306 7 54683156 6552306 8 5465892 652721 9 5465892 652721 1 5473198 653966 12 5475632 654381 13 5475632 654381 14 55480499 655212 15 5482932 655628 16 548536 656460 17 5487797 656460 18 5492659 657293 19 5492659 657293 10 5495690 657710 Cosine. Cotang. | | Cotang. | 1-539865 | 1.537905 | 1-535949 | 1-533996 | 1-532047 | 1.539102 | 1.528160 | 1.526221 | 1.524286 | 1-523320 | 1.522354 | 1.520426 | | |
| 83 Deg. Sine. 0 -5446390 2 -545145 3 -5453707 4 -5458145 6 -5461456 8 -5465892 9 -5465892 10 -54773198 11 -5473198 12 -5475632 13 -5475632 14 -5480499 15 -5480499 16 -5480499 17 -5480499 18 -5480499 19 -5490228 11 -5475632 11 -5475632 11 -5475632 11 -5475632 11 -5475632 11 -5475632 11 -5475632 11 -5475632 11 -5475632 11 -5480499 11 -5480499 11 -5480659 11 -5480659 | | Tang. | 649407 | 650235 | -651063 | 652306 | 652721 | -653551 | 654381 | 6555212 | 656044 | -656460 | -656877 | -657710 | Cotang. | |
| 8 - 10-88400 - 800 0 - 15 E 4 0 0 1 8 0 0 1 - | Deg. | Sine, | 5446390 | 5451269 | 5456145 | 5461020 | 5465892 | 5470763 | 5475632 | 5480499 | 5485365 | 5487797 | 5490228 | 5495090 | Cosine. | |
| | 23 | - | 0 | 0.5 00 | | | 80 00 | 10 | 132 | | 91 | 17 | 18 | 21 | - | |

| (| - | 6 | 18 | 2 | 9 | 2 | 4 | 65 | 6.5 | - | 0 | 6 | 00 | 7 | 0 | 2 | * | 60 | 65 | - | 0 | 1 | - |
|-------------------|---|------|--|---|--|--|---|---|--|--|--|--|---|--|---|--|--|--|--|--|--|--|-------------------|
| - | + | _ | 10 | -5596751 + 675355 + 695867 + 6928 + 69287 + 69287 + 691374 + 69287 + 69287 + 69287 + 69287 + 69286 + 69286 + 69287 + 69286 + 69286 + 69287 + 69286 + 69287 + 69286 + 69287 + 6927 | 27 1 | 1160 | - | 1 29 | 15 | 135 | 0 1 | 60 | 91 | 33 | 61 | 24 | 88 | 53 | 99 | 89 | 02 | | |
| sine | 1 | 308 | 144 | 978 | 812 | 646 | 481 | 315 | 148 | 983 | 817 | 650 | 484 | 318 | 151 | 985 | 818 | 655 | 485 | 318 | 115 | 80 | Sine. |
| Cotang. Cosine. | 1 | 822 | 822 | 821 | 821 | 821 | 821 | 821 | 821 | 820 | 820 | 820 | 820 | 820 | 820 | 818 | 818 | 818 | 818 | 818 | 818 | | 00 |
| tio | 1 | 81 | 83 | 98 | 89 | 94 | 99 | 04 | = | 18 | . 92 | 35 | 45 | 22 | 99 | 78 | 06 | 03 | 17 | 32 | 48 | | - |
| tan | 1 | 150 | 411 | 32 | 123 | 114 | 105 | 397 | 888 | 379 | 370 | 361 | 352 | 343 | 334 | 325 | 316 | 308 | 662 | 062 | 182 | | Tang. |
| ပိ | 1 | 1.44 | 1.44 | 1.44 | 14 | 1-44 | 1.44 | 1.48 | 1.45 | 1.45 | 1.48 | 1.43 | 1.45 | 1.48 | 1.45 | 1.4 | 1.43 | 1.4 | 1.45 | 1.45 | 1.4 | | |
| | 1 | 0.5 | 32 | 63 | 93 | 24 | 25 | 86 | 18 | 49 | 81 | 13 | 45 | 177 | 60 | 42 | 74 | 07 | 40 | 74 | 200 | - | Cosine, Cotang. |
| Tang. | | 920 | 924 | 928 | 932 | 937 | 941 | 945 | 950 | 954 | 958 | 963 | 967 | 971 | 976 | 086 | 984 | 989 | 993 | 997 | 000 | | otai |
| | 1 | 3.6 | 9.9 | 9.1 | 9. 1 | 9-8 | 9. 2 | 9. 1 | 9.9 | 9. 1 | 2.6 | 9.6 | 9-8 | 3.6 | 9-6 | 4.6 | 9-6 | 4.6 | 9.8 | 9.1 | 41.7 | | C |
| ie. | 1 | 040 | 842 | 918 | 757 | 966 | 335 | 174 | 713 | 52 | 16 | 53 | 899 | 100 | 145 | 384 | 355 | 198 | 660 | 338 | 929 | | ine. |
| Sine. | | 69 | 69 | 695 | 69 | 369 | 202 | 100 | 102 | 302 | 71 | 714 | 716 | 715 | 721 | 72: | 726 | 728 | 73(| 738 | 738 | 1 | Cos |
| sine / | + | 1.5 | 25 | 3 5 | 4.5 | 5.5 | 9 .5 | 7.5 | 8 .5 | 9.5 | 0 .5 | 1.5 | 50 | 30 | 4 5 | 5.5 | 6 -5 | 7 | 8 | 6 | 0.5 | - | |
| - | ٠ | 394 | 88 | 374 | 364 | 354 | 344 | 334 | 324 | 314 | 0.2 | 9 | 8 2 | 775 | 99 | 555 | 24.5 | 23 | 225 | 115 | 903 | | - |
| - | 1 | 35 | 202 | 18 | 35 8 | 31 8 | 17 3 | 32 3 | 96 | 99 | 32 3 | 14 2 | 35 2 | 16 2 | 36 2 | 15.2 | 34 2 | 201 | 59 2 | 35 | 51 5 | | |
| sin | 1 | 099 | 44 | 27 | = | 945 | 184 | 62(| 45 | 290 | 120 | 1961 | 1796 | 163 | 46 | 130 | 113 | 197 | 80 | 640 | 47 | 1 | Sine. |
| 2 | 1 | 825 | 825 | 828 | 825 | 824 | 824 | 824 | 854 | 824 | 824 | 855 | 823 | 825 | 825 | 825 | 825 | 855 | 852 | 825 | 825 | | O. |
| Cotang. Cosine. | 1 | 00 | 87 | 74 | 63 | 52 | 42 | 35 | 24 | 16 | 60 | 020 | 97 | 92 | 88 | 85 | 82 | 80 | 79 | 79 | 80 | | |
| tan | | 632 | 622 | 613 | 604 | 595 | 586 | 577 | 999 | 559 | 550 | 541 | 531 | 522 | 513 | 504 | 195 | 186 | 177 | 168 | 159 | | Tang. |
| ပြိ | 1 | 1.4 | 1.4 | 1.4 | 7 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 7 | 1.4 | 1.4 | 1.4 | 14 | 1.4 | 1.4 | 1.4 | 1.3 | × |
| | 1 | 33 | 098 | 187 | 14 | 41 | 69 | 96 | 24 | 152 | 81 | 60. | 37 | 99 | 95 | 24 | 53 | 83 | 12 | 42 | 72 | | , Cosine. Cotang. |
| Tang. | | 834 | 838 | 842 | 847 | 851 | 855 | 859 | 864 | 868 | 872 | 877 | 881 | 885 | 888 | 894 | 868 | 902 | 907 | 911 | 916 | | ota |
| - | 1 | 9. 1 | 9.6 | 9.0 | 9.0 | 9.0 | 9.6 | 9.8 | 9. 4 | 5.6 | 20.0 | 9-6 | 9-9 | 3.6 | 8 .6 | 3.6 | 9. 4 | 2.6 | 5.6 | 9.6 | 9.1 | | 0 |
| ie. | 1 | 246 | 186 | 727 | 196 | 207 | 146 | 989 | 926 | 166 | 106 | 645 | 885 | 125 | 36.1 | 604 | 843 | 083 | 322 | 199 | 801 | | ine |
| Sine. | 1 | 564 | 564 | 564 | 564 | 565 | 565 | 565 | 565 | 9999 | 999 | 999 | 999 | 567 | 567 | 567 | 267 | 899 | 568 | 899 | 999 | | Co |
| Sind / | + | - | 63 | 33 | 24 | 55 | 98 | 27 | 88 | 62 | 30 | 31 | 35 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 0 | | - |
| - | 1 | 602 | 595 | 58 | 575 | 999 | 555 | 54 | 53 | 52 | 51 | 500 | 19 | 18 | 47 | 16 | 15 | 44 | 13 | 12 | 41 | 40 | |
| · · | Ì | 16 | 49 | 21 | 93 | 64 | 34 | 03 | 72 | 40 | 80 | 74 | 40 | 90 | 70 | 34 | 97 | 60 | 22 | 83 | 43 | 03 | |
| Cosine. | | 903 | 887 | 871 | 854 | 838 | 822 | 908 | 789 | 773 | 757 | 740 | 724 | 708 | 691 | 675 | 658 | 642 | 626 | 609 | 593 | 577 | Sine. |
| Ö | 1 | 85 | .82 | .82 | .83 | .82 | 85 | .82 | 82 | .82 | 85 | .82 | .82 | 83 | .82 | .82 | .82 | .85 | .82 | .83 | .82 | .83 | a. |
| Cotang. | 1 | 199 | 531 | 20% | 773 | 346 | 916 | 993 | 890 | 144 | 221 | 862 | 376 | 155 | 535 | 315 | 969 | 178 | 198 | 345 | 929 | 114 | 7. |
| otal | | 182 | 181 | 081 | 179 | 178 | 177 | 941 | 941 | 175 | 174 | 173 | 172 | 171 | 071 | 691 | 891 | 191 | 991 | 165 | 165 | 164 | 8.11 |
| | 1 | 7 | 1 | 1 | - | 1 | 11.4 | - | 1 | 17 | 7-7 | - | - | 1 | 1.4 | 7 | 1-4 | - | - | | 7-1 | 1. | |
| Tang. | 1 | 508 | 931 | 355 | 779 | 202 | 626 | 050 | 475 | 899 | 324 | 749 | 174 | 566 | 024 | 450 | 875 | 301 | 727 | 153 | 580 | 900 | ano |
| Tar | | 674 | 674 | 675 | 675 | 949 | 876 | 677 | 677 | 677 | 678 | 678 | 679 | 649 | 680 | 089 | 089 | 681 | 681 | 683 | 682 | 683 | Soft |
| | 1 | 68 | 10 | 51 | 32 | 72 | 31 | 06 | 88 | 96 | 14 | 12 | 82 | 34 | 39 | 15 | 16 | 53 | 57 | -109 | 63 | 99 | 1 |
| Sine. | 4 | 119 | 434 | 167 | 916 | 115 | 388 | 63 | 187 | 120 | 36 | 600 | 84 | 80% | 332 | 992 | 082 | 304 | 328 | 352 | 376 | 001 | in |
| Sir Sir | | 555 | $\cdot 5594340 \cdot 674931 \cdot 1481631 \cdot 8288749 \cdot 59287 \cdot 5644869 \cdot 683860 \cdot 1462287 \cdot 8254420 \cdot 3842 \cdot 5692795 \cdot 692432 \cdot 144183 \cdot 8221440$ | 555 | $\cdot 5599162 \cdot 675779 \cdot 1 \cdot 479773 \cdot 6285493 \cdot 5724 \cdot 5649670 \cdot 684714 \cdot 1 \cdot 460463 \cdot 8251135 \cdot 3644 \cdot 5697577 \cdot 693293 \cdot 1 \cdot 442389 \cdot 8218127 \cdot 1 \cdot $ | $.5601572 \cdot 676202 \cdot 1.478846 \cdot 8283864 \cdot 562070 \cdot 685141 \cdot 1.459552 \cdot 824949 \cdot 3545 \cdot 5699968 \cdot 693724 \cdot 1.441494 \cdot 8216469 \cdot 1.441494 \cdot 1.44149 \cdot 1.$ | -5603981 -676626 1-477919 -8282234 55 26 -5654469 -685569 1-458642 -8247847 3446 -5702357 -694155 1-440599 -8214811 | -5606390 - 677060 + 476993 - 8280603 - 6427 - 5656868 - 685996 + 457732 - 8246202 - 3347 - 5704747 - 694586 + 439704 - 8213152 - 8246202 - 677060 - 67706 - 694586 | -5608798 - 677475 - 174068 - 8278972 - 5328 - 5659267 - 686424 - 456824 - 8244556 - 3248 - 5707136 - 695018 - 1738811 - 8211492 - 12387 - 12 | $\cdot 5611206 \cdot 677899 \cdot 1 \cdot 475144 \cdot 8277340 \cdot 529 \cdot 5661665 \cdot 686852 \cdot 1 \cdot 455916 \cdot 8242909 \cdot 3149 \cdot 5709524 \cdot 695449 \cdot 1 \cdot 437918 \cdot 8209832 \cdot 1 \cdot 455916 \cdot 1 \cdot 475144 \cdot 1 \cdot 4$ | $\cdot 5613614 \cdot 678324 \cdot 1\cdot 474221 \cdot 8275708 \cdot 51 \cdot 30 \cdot 5664062 \cdot 687281 \cdot 455009 \cdot 8241262 \cdot 30 \cdot 50 \cdot 5711912 \cdot 695881 \cdot 1\cdot 437026 \cdot 8208170 \cdot 1008170 \cdot 10$ | $\cdot 6616021 \cdot 678749 \cdot 1 \cdot 473298 \cdot 8274074 \cdot 50 \cdot 31 \cdot 5666459 \cdot 687709 \cdot 1 \cdot 454102 \cdot 8239614 \cdot 29 \cdot 51 \cdot 5714299 \cdot 696313 \cdot 1 \cdot 436135 \cdot 8206509 \cdot 1 \cdot 436135 $ | $11.5618428.679174 \\ 1.472376 \\ 1.8276 \\ 1.8237965 \\ 2.868866 \\ 1.458197 \\ 1.458197 \\ 1.458197 \\ 1.8237965 \\ 2.865846 \\ 1.8287965 \\ 2.8688 \\ 1.8287965 \\ 1.8688 \\ 1.$ | $2.5620834 \cdot 679599 \cdot 471455 \cdot 8270806 \cdot 4833 \cdot 5671252 \cdot 688566 \cdot 452292 \cdot 9236316 \cdot 2753 \cdot 5719073 \cdot 697177 \cdot 1 \cdot 434355 \cdot 8203183 \cdot 27197 $ | $.5623239 \cdot 680024 \cdot 1.470535 \cdot 8269170 \cdot 47 \cdot 34 \cdot 5673618 \cdot 688995 \cdot 1.451388 \cdot 8234666 \cdot 26 \cdot 5721459 \cdot 697609 \cdot 1.433466 \cdot 8201519$ | $4^{+}5625645 \cdot 680450 \cdot 1469615 \cdot 8267534 \cdot 46 \cdot 36 \cdot 5676043 \cdot 689424 \cdot 1450485 \cdot 8233015 \cdot 2555 \cdot 5723844 \cdot 698042 \cdot 1432578 \cdot 8199854 \cdot 1436667 \cdot 1436667 \cdot 1436667 \cdot 1436678 \cdot 1436678 \cdot 1436678 \cdot 1436678 \cdot 1436678 \cdot 1436678 \cdot 1466678 \cdot 14666$ | $5.5628049 \cdot 680875 \cdot 1.468696 \cdot 8265897 \cdot 45 \cdot 366 \cdot 5678437 \cdot 689853 \cdot 1.449582 \cdot 8231364 \cdot 24 \cdot 56 \cdot 5726229 \cdot 698474 \cdot 1.431690 \cdot 8198189 \cdot 1.449988 \cdot 1.44988 \cdot 1.449988 \cdot 1.44988 \cdot$ | $6.5630453 \cdot 681301 \cdot 1 \cdot 467778 \cdot 8264260 \cdot 44 \cdot 37 \cdot 5680832 \cdot 690283 \cdot 1 \cdot 448680 \cdot 8229712 \cdot 23 \cdot 5728614 \cdot 698907 \cdot 1 \cdot 430803 \cdot 8196523 \cdot 6728614 \cdot 698907 \cdot 1 \cdot 480803 \cdot 8196523 \cdot 688081 \cdot 1 \cdot 48880 \cdot 1 $ | $17.5632857.681727 \\ 1.466861.82626224338.5680215.690712 \\ 1.447779.8228059.2268.5730998.699340 \\ 1.429917.8194856 \\ 1.447779.8228059.2268.591728194856 \\ 1.447779818181818181818181818181818181818181$ | $-5635260 - 682153 \cdot 1 -465945 \cdot 8260983 \cdot 42 \cdot 39 \cdot 5685619 \cdot 691142 \cdot 1 -446879 \cdot 8226405 \cdot 2159 \cdot 5733381 \cdot 699774 \cdot 1 \cdot 429032 \cdot 8193189 \cdot 5733381 \cdot 699774 \cdot 1 \cdot 429032 \cdot 8193189 \cdot 699774 \cdot 1 \cdot 429032 \cdot 819774 \cdot 1 \cdot 429032 \cdot 819774 \cdot 1 \cdot 429032 \cdot 81974 \cdot 1 \cdot 429032 \cdot 81974 \cdot 1 \cdot 429032 \cdot 81974 \cdot 1 \cdot 429032 \cdot 1$ | $19.5637663 \cdot 682580 \cdot 1465029 \cdot 8259343 \cdot 4140 \cdot 5688011 \cdot 691572 \cdot 1445980 \cdot 822475 \cdot 2060 \cdot 5735764 \cdot 700207 \cdot 1428148 \cdot 8191520 \cdot 5637667 \cdot 5735764 \cdot 700207 \cdot 1428148 \cdot 8191520 \cdot 1428148 \cdot 142818 \cdot 1428148 \cdot 1428148 \cdot 1428148 \cdot$ | 20 -5640066 -683006 1-464114 -8257703 40 | Cotang. Cotang. |
| | | | | | 00 | | 2 | | - | | 6 | - | - | - | - | - | - | | - | 00 | - | - | - |

| | 1 | 113 4 5 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | 8816 | 1-1 |
|--|-----------------|---|---|-----------------|
| | Cosine. | $\begin{array}{c} \textbf{5735764} & 700207 & 1.428148 \\ \textbf{5738764} & 700207 & 1.428148 \\ \textbf{5778147} & 700641 & 1.427264 \\ \textbf{58189852} & 5922 & 5788069 \\ \textbf{57798147} & 700641 & 1.427264 \\ \textbf{58189852} & 5922 & 5788069 \\ \textbf{57798147} & 700641 & 1.427264 \\ \textbf{5818982} & 5823 & 5799440 \\ \textbf{57708291} & 710225 & 1.408003 \\ \textbf{5742911} & 7010641 & 1.427264 \\ \textbf{5782911} & 701074 & 1.42617 \\ \textbf{5782912} & 7701943 & 1.42617 \\ \textbf{57729212} & 7701943 & 770495 \\ \textbf{57729212} & 7701943 & 770495 \\ \textbf{57729213} & 7701943 & 770495 \\ \textbf{57729213} & 7701943 & 7701943 \\ \textbf{57729213} & 7701943 & 7701943 \\ \textbf{5772023} & 7701943 & 7701943 \\ \textbf{57720324} & 7701944 \\ $ | 8095296 -8093588 -8091879 -8090170 | Sine. |
| | Cotang. | 0. 6736764 70207 1-428148 8191520 60 21 5738069 709379 1-40871 81526330 3941 5833612 71813 1-392501 81226332 1-5738147 700641 1-427264 8189852 5925 578069 709787 1-40807 8152963 3743 5835412 71867 819087 81913137 81913137 81913137 81913137 81913137 81913137 81913137 81913137 81913137 81913137 81913137 81913137 81914040 8174291 700000 8191314040 8177409 8174291 700000 8181409 817400 8117409 817400 8117400 817400 817400 8117400 817400 | $\begin{array}{c} 1.5776202.7776202.1413322.8616305643138.7582599.7165911.395927.81831478317799.7252101.378910.8095296\\ 1.5776502.777602.1413322.8616305643138.592599.7166101.395069.9127620.2526.5873145.7256441.379204.8991388\\ 1.5778576.7077602.14133250.81613764299.59289523.777223.777223.8125925.2159.5875499.7256081.777224.89913789\\ 1.5786950.707602.1411479.81596954140.5830687.7776911.393357.8124229.20.60.5877853.77266421.376381.8099177\\ 1.5786323.377859131.410609.815801340\\ 1.57863323.77857827.8559778553.77265421.376381.8099177\\ 1.576837857.778578785977867789777278991777278991777278991777278997777777777$ | Tang. |
| | Tang. | 718131 718572 719014 719455 719897 720780 721222 72165 72250 72250 72250 72250 72250 722432 | 725210 725654 726698 726542 | Cotang. |
| | Sine. | 5833050 5835412 5837774 5840136 5842497 5847217 5849577 5849577 5849577 5849577 5849577 586652 588196 586652 5881367 586652 | 5873145 5873145 5875499 5877853 | Cosine. Cotang. |
| | _ | 144444444444444444444444444444444444444 | 298. | - |
| | - | 07 8 8 8 9 9 8 8 8 8 8 8 8 8 8 8 8 8 8 8 | 9 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | - |
| | Cosine | 815633 815464 815495 815127 814959 814453 814453 814453 814453 814453 813946 813946 813777 813608 813439 813439 813439 813439 | .812331 .812762 .812422 | Sine. |
| | Cotang. | 409740 408871 40803 407136 404539 140870 404539 1403674 1403674 1402811 1401086 1401086 1400234 1399363 1398503 1398503 1398503 | .395069 .394213 .393357 | Tang. |
| | Tang. | 709350 709787 710623 71100 71197 712415 712854 712854 713293 713293 713732 714610 715050 715020 | 716810 717250 717691 | Jotang. |
| , | Sine. | 7785696 77890440 7792812 7792812 779583 7799923 5802292 5807030 5807030 581755 581755 581755 581755 581755 581755 581755 581755 | 5825959 - 5825959 - 5830687 - | Cosine. Cotang. |
| 1000 | - | 1 | 100 | - |
| | | 660 600 600 600 600 600 600 600 600 600 | 44444 | |
| | Cosine, | 8191520 8189852 818182 818182 818461 818461 818461 8179824 8179824 8171851 8174801 8174401 8174401 8169094 8169094 | 8158013 8158013 8159695 8158013 | Sine. |
| | Cotang. Cosine, | 428148 427264 425498 424617 423256 421976 4219776 4219320 4219320 419340 417590 417590 417590 417590 417590 417590 417590 417590 417590 417590 417590 417590 | 413222 412350 411479 410609 | Tang. |
| The state of the s | 'Fang | 700207 700641 701074 701093 701943 702371 702371 70361 70455 70455 70455 70455 70455 70455 70456 705558 | 707602 708039 708476 708476 | Cotang. |
| | Sine. | 0.0735764 · 700207 1. 5738147 · 700641 2. 5740529 · 701074 3. 5742291 · 701508 4. 5745292 · 701943 5. 5750053 · 70237 7. 5752432 · 703246 8. 5750053 · 702346 8. 575190 · 704116 9. 575190 · 704116 9. 575190 · 70452 1. 5764323 · 705422 3. 5764323 · 705422 3. 5764323 · 705422 4. 5769076 · 706294 5. 5771452 · 706393 6. 5773887 · 706393 | 17.5778576 -708039 1.418329 -8163056 43 18.5778576 -708039 1.418350 -8161376 42 19.5780950 -708476 1.411479 -8159695 41 20.5783323 -708913 1.410609 8158013 40 | Cosine, Cotang: |
| | - 1 | 0-0004607000100400 | 2000 | - |

| | | | | - | - | | 7 | - | | - | , | - | | | | | ~, | - | | | | | | |
|---------|---------------------------|---|--|---|--|--|--|--|--|---|--|--|--|---|---|---|--|--|---|--|---|--|-------------------------|----------|
| | - | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 6 | 00 | 1 | 9 | 5 | 4 | * | 53 | 1 | 0 | | - | 53. |
| | Cosine. | -8090170 6021 -5927163 -735917 1-358848 -8054113 3941 -5973919 -744921 1-342417 -8019495 19 | 1-341602 -8017756 | 5882558 727431 1.374699 8086749 5823 5931847 736814 1.357193 8050664 3743 5978583 745829 1.340788 8016018 | +373859 + 8085037 + 5724 + 5934189 + 737263 + 356367 + 8048938 + 3644 + 5980915 + 746282 + 339975 + 8014278 + 8014 | 5887502 728321 1 373019 8083325 5625 5936530 737712 1 355541 8047211 3545 5983246 746735 1 33162 8012538 | $\frac{5886613}{5886613} \cdot \frac{728767}{572180} \cdot \frac{1.372180}{5086162} \cdot \frac{128767}{5686613} \cdot \frac{128767}{5886613} \cdot \frac{128767}{588613} \cdot \frac{128767}{588613} \cdot \frac{128767}{588610} \cdot \frac{128767}{$ | $\cdot 371342 \cdot 8079899 \cdot 5427 \cdot 5941211 \cdot 738611 \cdot 1353891 \cdot 8043756 \cdot 3347 \cdot 5987906 \cdot 747642 \cdot 1337538 \cdot 8009056 \cdot 371342 \cdot 100000000000000000000000000000000000$ | 8007314 | 8005571 | 1.351422 -8038569 30 50 -5994893 -749003 1.335107 -8003827 | 8002008 | 80000338 | 332682 -7998593 | 7996817 | -7995100 | 7993352 | -7991604 | .7989855 | $\cdot 5920132 \cdot 7345731 \cdot 361335 \cdot 80592834289 \cdot 5969252 \cdot 744020 \cdot 344049 \cdot 8022969 \cdot 2169 \cdot 6015927 \cdot 753098 \cdot 1 \cdot 327848 \cdot 7988105 \cdot 5920132 \cdot 7345731 \cdot 327848 \cdot 753098 \cdot 75$ | $\cdot 3922476 \cdot 735021 \\ 1\cdot 360505 \cdot 8057560 \\ 4140 \cdot 5971586 \cdot 744472 \\ 1\cdot 343233 \cdot 8021232 \\ 20 \\ 60 \cdot 6018150 \cdot 753554 \\ 1\cdot 327044 \cdot 7986355 \\ 1\cdot 377044 \cdot 7986355 \\ 1\cdot 37704 \cdot 798635 \\ 1\cdot 37704 \cdot 7$ | | Sine. | Deg. 53. |
| | Cotang. | 1-342417 | 1.341602 | 1.340788 | 1-339975 | 1.339162 | 1-338350 | 1.337538 | 1-336727 | 352244 8040299 31 49 5992565 748549 1-335917 8005571 | 1-335107 | 1.334298 8002083 | 1-333490 | 1-332682 | 1-331875 | 1-331068 | 1-330262 | .345683 8026440 23 57 6011179 752186 1.329457 7991604 | .344865 -8024705 22 58 -6013503 -752642 1-328652 -7989855 | 1-327848 | 1-327044 | | Tang. | |
| | Tang. | .744924 | .745377 | .745829 | -746282 | .746735 | .747188 | .747642 | .748095 | .748549 | -749003 | ·749457 | ·749911 | .750366 | 1280921 | .751276 | .751731 | .752186 | .752642 | -753098 | -753554 | | Cotang. | |
| 36 Deg. | Sine. | -5973919 | -5976251 | -5978583 | -5980915 | -5983246 | 5985577 | 5987906 | .353068 -8042028 32 48 -5990236 -748095 1-336727 | 5992565 | 5994893 | 350600 8036838 29 51 5997221 749457 1 | 5999549 | 6001876 | 6004202 | -6006528 | 6008854 | 6011179 | 6013503 | 6015827 | .6018150 | | / Cosine, Cotang, Tang. | |
| 36 | - | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 25 | 53 | 54 | 55 | 56 | 57 | 89 | 69 | 09 | | - | |
| | - | 3 39 | 38 | 1 37 | 3 36 | 35 | 1 34 | 333 | 332 | 31 | 30 | 8 29 | 28 | 5 27 | 36 | 125 | 5 24 | 23 | 5 22 | 321 | 2 20 | | - | 58 |
| | Cosine. | -8054113 | 8052389 | 8050664 | 8048938 | 8047211 | 8045484 | 8043756 | 8042028 | 8040299 | 8038569 | 8036838 | 8035107 | 8033375 | 8031642 | 8053908 | 8028175 | 8026440 | ·802470 | 8022969 | 802123 | | Sine. | Dec. 53 |
| | Tang. Cotang. | 1.358848 | 1.358020 | 1-357193 | 1-356367 | 1-355541 | 1-354716 | 1-353891 | 1-353068 | 1-352244 | 1.351422 | 1.350600 | 1-349779 | 1-348958 | 1-348139 | 1-347319 | 1-346501 | .345683 | 1,344865 | 344049 | 1,343233 | | Tang. | |
| | Tang. | 735917 | .736366 | .736814 | 737263 | 737712 | .738162 | 738611 | 190681 | 739511 | 739961 | 740411 | 740861 | .741312 | 741763 | 742214 | 742665 | 743117 | .743568 | 744020 | 744472 | | Cotang. | |
| 36 Deg. | Sine. | 5927163 | 5929505 | 5931847 | 5934189 | 5936530 | 5938871 | 5941211 | 5943550 | 5945889 | 5948228 | 5950566 | 5952904 | 5955241 | 5957577 | 5959913 | 5962249 | 5964584 | 5966918 | 5969252 | 5971586 | | / Cosine. Cotang. | |
| 36 | - | 123 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | | - | |
| | , | 60 | 59 | 58 | 57 | 96 | 55 | 54 | 53 | 52 | 51 | 50 | 49 | 48 | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 40 | - | 53 |
| | Tang. Cotang. Cosine. | 0210608- | 8088460 | 8086749 | 8085037 | 8083325 | 8081612 | 8079899 | 8078185 | 8076470 | 8074754 | 8073038 | -8071321 | 8096908 | -8067885 | 8066166 | $-363827 \cdot 8064446 \cdot 45 \cdot 36 \cdot 5962249 \cdot 742665 \cdot 742665 \cdot 78938175 \cdot 24 \cdot 56 \cdot 6008854 \cdot 751731 \cdot 330262 \cdot 7993352 \cdot 788827 \cdot 806446 \cdot 45 \cdot 788867 \cdot 78886$ | 8062726 | 8061005 | 8059283 | 8057560 | -8055837 | Sine. | Dog |
| | Cotang. | 1-376381 | 1-375540 | 1.374699 | 1.373859 | 1.373019 | 1.372180 | 1.371342 | 1.370504 | 1.369667 | 1-368831 | 1.867995 | 1.367161 | 1.366326 | 1.365493 | 1.364660 | 1.363827 | 1.362996 | 1-362165 | 1-361335 | 1-360505 | 1-359676 | Tang. | |
| | Tang. | 726542 | 726987 | .727431 | .727876 | .728321 | 728767 | .729212 | .729658. | .730104 | .730550 | 730996 | -731442 | .731889 | -732336 | .732783 | .733230 | 7733677 | .734125 | .734573 | -735021 | -735469 | Cotang. | |
| 36 Deg. | Sine. | -5877853 -726542 1-376381 | 5880206 726987 1 375540 8088460 5922 5929505 736366 1 358020 8052389 3842 5976251 745377 1 | 5882558 | -5884910 -727876 | 5887262 | 5889613 | -5891964 -729212 | -5894314 -729658 1-370504 -8078185 5328 -5943550 -739061 | -5896663-730104 1-369667 8076470 52 29 -5945889 -739511 | -5899012 -730550 1-368831 -8074754 51 30 -5948228 -739961 | 0.5901361 -73099611-367995 -8073038 50 31 -5950566 -740411 | -5903709 - 731442 = 367161 - 8071321 + 49 = 32 - 5952904 - 740861 = 349779 - 8035107 = 852 - 5999549 - 749911 = 333490 - 8000338 = 80000338 = 80000338 = 80000338 = 80000338 = 80000338 = 80000338 = 80000338 = 80000338 = 80000338 = 80000338 = 8000038 = 8000038 = 8000038 = 8000038 = 80000000000 | 9.5906657.7318891.366326.8069603 48 33.5955241.741312 1.348958.8033375 27 53.6001876.75036611 | $3.5908404 - 732336 \\ 1.365493 - 8067885 \\ 47734 - 5957577 - 741763 \\ 1.348139 - 8031642 \\ 2654 - 6004202 - 750821 \\ 1.331875 - 7996847 \\ 2.654 - 6004202 - 750821 \\ 1.331875 - 7996847 \\ 2.654 - 6004202 - 750821 \\ 1.331875 - 7996847 \\ 3.5908404 - 732336 \\ 1.348139 - 76082 - 76082 \\ 1.348139 - 76082 - 76082 \\ 1.348139 - 76082 - 76082 \\ 1.348139 - 76082 - 76082 \\ 1.348139 - 76082 \\ 1.348129 - 76082 \\ 1.348139 - 76082 \\ 1.348129 -$ | -59107501-7327831-364660-80661664635-5959913-7422141-347319-802990925555-6006528-7512761-331068-7995100 | -5913096 -733230 | -5915442 -733677 1-362996 -8062726 4437 -5964584 -743117 1 | -5917787 -734125 1-362165 -8061005 43 38 -5966918 -743568 1 | 5920132 | 5922476 | 20 -5924819 -735469 1-359676 -8055837 40 | Cosine. | |
| 36 1 | 1- | 10 | - | 67 | | 4 | 117 | | | | | 10 | - | 19 | 13 | 14 | 10 | 18 | 17 | 8 | 19 | 20 | - | 1 |
| .6 | | _ | _ | | | | | - | | | | | | | | - | | | | | - | | | |

NATURAL SINES AND TANGENTS TO A RADIUS 1.

| ne. | 887 99 97 99 98 79 | |
|---------|--|-----------------|
| ne. | | |
| Cosine. | 7914014 791223 791223 7908697 790687 7905116 78976 78976 78978 789694 789984 789984 789984 789984 789984 789984 789984 789984 789984 789984 789984 7889084 7889084 7889084 7889084 7889084 7889084 7889084 7889084 7889084 | Sine. / |
| Cotang. | 1.294627 1.2936348 1.293274 1.291517 1.290742 1.28192 1.288418 1.286871 1.28689 1.286871 1.28689 1.28376 1.283 | Tang. |
| Tang. | 772423 773352 773352 774381 774381 775213 775213 77761 77701 77701 77701 77701 77701 77701 778916 778916 778916 778916 778916 | Cotang. |
| Sine. | 6112969 6115270 6119873 6122173 6122173 6126772 6129071 6131369 613566 6135866 6135866 614742 614742 614742 616615 6156615 | Cosine. |
| | 14444444444444444444444444444444444444 | - |
| - | 8866866866686686686868686868686 | - |
| Cosine. | 794944 7945918 794414 794237 794237 793884 793853 793530 792899 792899 792899 79289 79289 79289 792189 792189 791934 791934 791934 | Sine. |
| Cotang. | 310314 -309523 -308734 -307157 -307157 -305582 -305582 -304796 -301656 -300873 -300873 -300873 -399308 -299308 -299308 -2995064 -296185 | Tang. |
| Tang. | 763175 764096 764096 765018 765918 765940 76789 76789 76789 76789 76789 76789 76789 77719 771039 7711039 | Cotang. |
| Sine. | 6.6018150 -758554 1-327044 -7984604 50 22 -6069136 -763175 1-310314 -7945048 3842 -615270 -772887 1-293071 -791401 1.6022473 -754401 1-325242 -7994604 50 22 -6069136 -765361 1-309523 -7941405 -7944104 -794601 -7993071 -7993071 -7993071 -7993071 -79984604 -7994100 -7724 -607147 -764096 1-306527 -7944104 -7945071 -7998460 -79984604 -7994100 -7946060 -76501 -7944104 -74478 -7998460 -7908606 -794601 -7944104 -74478 -797877 -790877 -790877 -790877 -79787 -79878 -79787 -79787 | Cosine. Cotang. |
| l' Si | 40 40 40 40 40 40 40 40 40 40 | 1 |
| - | 090 050 050 050 050 050 050 050 050 050 | - |
| Cosine. | 7986355 7984604 7982853 797594 797594 797594 797594 797594 797596 7967058 7967058 7967058 7967058 7967058 7967058 7967058 7967058 7967058 7967058 7967058 7967058 7967058 7967058 7967058 7967058 7967058 7967058 7967058 | Sine. |
| Cotang. | 1-327044 1-326439 1-326439 1-326439 1-32237 1-32237 1-32036 1-319044 1-318655 1-318655 1-31865 1-31865 1-31884 1-31886 | Tang. |
| Tang. | 6018150 753554 6020473 7754010 6022795 7754101 6022795 7754101 6022795 7754101 6022795 7754101 6023208 7756751 603410 7757666 6041356 7758124 6045991 7757666 6041356 7758124 6045991 775989 6052624 775958 605294 775917 6055255 776917 776917 776717 6055255 776917 776917 776717 6055255 776917 776917 776717 6055255 776917 776917 776717 6055255 776917 776917 776717 6055255 776917 776917 776717 6055255 776917 776717 776 | Cotang. |
| Sine. | Constant | Cosine. |
| - | 0 - 1 2 2 4 2 3 7 1 0 0 0 8 4 2 3 7 1 8 6 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | 1- |

| | _ | 10 | | 1 2 | | | _ | - | 45 | | _ | - | 00 | h | 100 | 100 | - | ~ | 03 | | - | _ | 1 - |
|---------|-----------------|---|--|--|--|---|--|--|--|---|--|--|--|---|--|--|--|--|--|---|---|--|-----------------|
| 1 | 7-1 | 3 18 | 1 18 | 5 | 3116 | 5115 | 1 | 2 13 | 0 15 | 7 11 | 3 10 | 6 | 1 | 3. | 1 6 | - | 7 4 | 6 | 0.5 | 10 | 0 | 7 | - |
| | Cosine. | 6156615 781285 1.279941 7890108 60 21 6204636 791170 1.263950 7842352 3941 6250156 800673 1.248948 7806123 19 | $-6158907 \cdot 781754 \cdot 1279174 \cdot 7878316 \cdot 59128 \cdot 6206917 \cdot 791643 \cdot 1263195 \cdot 7840547 \cdot 3842 \cdot 6252427 \cdot 801151 \cdot 1248204 \cdot 7804304 \cdot 1804304 \cdot 1804404 \cdot 180404 \cdot 1804404 \cdot 18$ | $-6161198 \cdot 7822221 \cdot 278407 \cdot 7876524 \cdot 5823 \cdot 6209198 \cdot 7921161 \cdot 262440 \cdot 7838741 \cdot 3743 \cdot 6254696 \cdot 801628 \cdot 247460 \cdot 7832485 \cdot 17832485 \cdot 1783248 \cdot 1783248 \cdot 17832486 \cdot 1783248 | $-6163489 \cdot 782691 \cdot 277641 \cdot 7874732 \cdot 5724 \cdot 6211478 \cdot 792590 \cdot 261686 \cdot 7836935 \cdot 3644 \cdot 6256966 \cdot 802106 \cdot 24576 \cdot 7800665 \cdot 1200665 \cdot 12006665 \cdot 1200665 \cdot 1200665 \cdot 1200665 \cdot 1200665 \cdot 1200665 \cdot 1200665 \cdot 12006665 \cdot 12006665 \cdot 120$ | 6165780 783161 1.276876 7872939 56 25 6213757 793064 1.260932 7835127 3545 625935 802584 1.245974 77388 15 15 | $-6168069 \cdot 783630 \cdot 1.276111 \cdot 7871145 \cdot 55 \cdot 26 \cdot 6216036 \cdot 793537 \cdot 7260179 \cdot 7833320 \cdot 3446 \cdot 6261503 \cdot 803063 \cdot 1.245232 \cdot 7797021 \cdot 1446 \cdot 6261503 \cdot 803063 \cdot 1.245232 \cdot 7797021 \cdot 1446 $ | $-6170359 \cdot 784100 \cdot 1.275347 \cdot 7869350 \cdot 5427 \cdot 6218314 \cdot 794012 \cdot 1.259426 \cdot 7831511 \cdot 3347 \cdot 6263771 \cdot 803541 \cdot 244490 \cdot 77952.12 \cdot 138878 \cdot 138878 \cdot 13888 \cdot 1388$ | $-6172648 \cdot 784570 \cdot 1 \cdot 274583 \cdot 7867555 \cdot 53 \cdot 28 \cdot 6220592 \cdot 794486 \cdot 1 \cdot 258674 \cdot 7829702 \cdot 3248 \cdot 6266038 \cdot 804020 \cdot 1 \cdot 245749 \cdot 7783380 \cdot 128678 \cdot 1$ | $-6174936 \cdot 785040 \cdot 1 \cdot 273820 \cdot 7865759 \cdot 6222870 \cdot 794961 \cdot 767923 \cdot 7827892 \cdot 3149 \cdot 6268305 \cdot 804499 \cdot 243008 \cdot 7791557$ | $-6177224 \cdot 785510 \cdot 1.273057 \cdot 7863963 \cdot 51 \cdot 30 \cdot 6225146 \cdot 795435 \cdot 1.257172 \cdot 7826082 \cdot 30 \cdot 50 \cdot 6270571 \cdot 804979 \cdot 1.242268 \cdot .7789733 \cdot 1.2789733 \cdot 1.278973 \cdot 1.$ | $-6179511 \cdot 785980 \cdot 1 \cdot 272295 \cdot 7862165 \cdot 50 \cdot 31 \cdot 6227423 \cdot 795911 \cdot 1 \cdot 256421 \cdot 7824270 \cdot 2951 \cdot 6272837 \cdot 805458 \cdot 1 \cdot 241529 \cdot 7787909 \cdot 1 \cdot $ | $\cdot 6181798 \cdot 786451 \cdot 1.271534 \cdot 7860367 \cdot 49 \cdot 32 \cdot 6229698 \cdot 796386 \cdot 1.255672 \cdot 7822459 \cdot 2852 \cdot 6275102 \cdot 805938 \cdot 1.240790 \cdot 7786084 \cdot 1.271798 \cdot 1.271798 \cdot 1.271799 \cdot 1.27179 $ | $\cdot 6184084 \cdot 786922 \cdot 1 \cdot 270773 \cdot 7858569 \cdot 48 \cdot 83 \cdot 6231974 \cdot 796861 \cdot 1 \cdot 254922 \cdot 7820646 \cdot 2753 \cdot 6277366 \cdot 806418 \cdot 1 \cdot 240051 \cdot 7784258 \cdot 1 \cdot 240051 \cdot 778458 \cdot 1 \cdot 240051 \cdot 778458 \cdot 1 \cdot $ | $-6186370 \cdot 787393 \cdot 1 \cdot 270013 \cdot 7856770 \cdot 47 \cdot 34 \cdot 6234248 \cdot 797337 \cdot 1 \cdot 254174 \cdot 7818833 \cdot 2654 \cdot 6279631 \cdot 806898 \cdot 1 \cdot 239313 \cdot 77828131 \cdot 7782811 | $\cdot 6188655 \cdot 787864 \cdot 1 \cdot 269253 \cdot 7854970 \cdot 46 \cdot 35 \cdot 6236522 \cdot 797813 \cdot 1 \cdot 253426 \cdot 7817019 \cdot 255 \cdot 6281894 \cdot 807378 \cdot 1 \cdot 238576 \cdot 7780604 \cdot 1 \cdot 238576 \cdot 7880604 \cdot 1 \cdot 238576 \cdot 1 \cdot $ | $5 \cdot 6190939 \cdot 788336 \cdot 1 \cdot 268494 \cdot 7853169 \cdot 45 \cdot 36 \cdot 6238796 \cdot 798289 \cdot 1 \cdot 252678 \cdot 7815205 \cdot 24 \cdot 56 \cdot 6284157 \cdot 807859 \cdot 7778777 \cdot 807859 \cdot 7778777 \cdot 807859 \cdot 7778777 \cdot 807859 \cdot 77787777 \cdot 807859 \cdot 77787777 \cdot 807859 \cdot 77787777 \cdot 807859 \cdot 7778777 \cdot 807859 \cdot 77787777 \cdot 807859 \cdot 77787777 \cdot 807859 \cdot 7778777 \cdot 807859 \cdot 777877 \cdot 807859 \cdot 77787 \cdot 80787 \cdot 8077 \cdot 80787 \cdot 8077 \cdot 807$ | $ \begin{array}{c ccccccccccccccccccccccccccccccccccc$ | $7 6195507 \cdot 789280 1.266977 \cdot 7849566 43 38 \cdot 6243342 \cdot 799242 1.251184 \cdot 7811574 22 58 \cdot 6288682 \cdot 80882 1.236367 \cdot 7775 20 \cdot 6288682 \cdot 80882 1.236367 \cdot 7775 20 \cdot 6288682 \cdot 80882 \cdot 80882 1.236367 \cdot 7775 20 \cdot 6288682 \cdot 80882 \cdot$ | $8.6197790 \cdot 789752 \cdot 1.266219 \cdot 7847764 \cdot 4239 \cdot 6245614 \cdot 799719 \cdot 1.250438 \cdot 7809757 \cdot 2159 \cdot 6290943 \cdot 809302 \cdot 1.225631 \cdot 7773290$ | $19.6200073 \cdot 790224 \cdot 1.265462 \cdot 7845961 \cdot 41 \cdot 40 \cdot 6247885 \cdot 800196 \cdot 1.249693 \cdot 7807940 \cdot 2060 \cdot 6293204 \cdot 809784 \cdot 1.234897 \cdot 7771460$ | | Sine. |
| 1 | 000 | 780 | 780 | 783 | 780 | 977 | 977 | 977 | 779 | 779 | 778 | 778 | 778 | 778 | 778 | 778 | 777 | TTT. | 777 | 777 | 177 | | 02 |
| - 14 | _ | 148 | 0.4 | 09 | 116 | 74 | 35 | 06 | 49 | 800 | 89 | 629 | 06 | 119 | 113 | 94 | 339 | 0.3 | 198 | 189 | 1268 | | 1 : |
| 1 | Cotang. | 489 | 482 | 474 | 467 | 459 | 452 | 444 | 437 | 430 | 422 | 415 | 407 | 400 | 393 | 385 | 378 | 371 | 363 | 356 | 348 | | Tang. |
| | | 1.5 | 1.2 | 1-2 | 1-9 | 6-1 | 1.2 | 1.2 | 1-2 | 1.2 | 1.2 | 1.2 | 11.2 | 11.2 | 111-2 | 1-2 | 1.2 | 1.9 | - | 1.5 | 1.9 | | |
| | Tang. | 673 | 151 | 628 | 106 | 584 | 690 | 1541 | 020 | 499 | 979 | 158 | 938 | 418 | 868 | 378 | 859 | 340 | 1881 | 302 | 1784 | | ang |
| 1 | 18 | 800 | 801 | .801 | .802 | -802 | -803 | 803 | 804 | -804 | 804 | 805 | 805 | 908- | 908 | 108 | .807 | 808 | 808 | 808 | 808 | | Cosine. Cotang. |
| 1 | | 156 | 127 | 969 | 996 | 335 | 503 | 771 | 38 | 305 | 571 | 337 | 102 | 998 | 931 | 394 | 157 | 120 | 883 | 943 | 204 | 1 | 96 |
| | Sine. | 250 | 252 | 254 | 256 | 259 | 261 | 263 | 366 | 268 | 270 | 272 | 275 | 277 | 279 | 281 | 284 | 286 | 288 | 290 | 293 | | Osi |
| - | | 9. 1 | 2 .6 | 3 .6 | 4 .6 | 9. 9 | 9-19 | 9-14 | 9.8 | 9- 6 | 9.0 | 1 .6 | 2 -6 | 3.6 | 9- 4 | 9.19 | 9.9 | 9. 1 | 9.8 | 9- 6 | 9.0 | - | - |
| 1 | | 394 | 384 | 374 | 364 | 354 | 344 | 334 | 324 | 314 | 305 | 295 | 285 | 275 | 265 | 255 | 245 | 235 | 22,5 | 215 | 206 | | - |
| 1 | 6. | 52 | 17 | 41 | 35 | 27 | 500 | 11 | 00 | 92 | 82 | 70 | 59 | 46 | 33 | 19 | 05 | 06 | 74 | 57 | 40 | | - |
| | Cosine. | 423 | 405 | 387 | 369 | 351 | 333 | 315 | 297 | 278 | 260 | 242 | 224 | 206 | 188 | 170 | 152 | 133 | 115 | 760 | 079 | | Sine. |
| | | .78 | .78 | .78 | .78 | .78 | 1.78 | .78 | .78 | .78 | .78 | .78 | .78 | .78 | .78 | .78 | .78 | ·78 | .78 | -78 | .78 | | 4 |
| | Cotang. | 950 | 195 | 440 | 686 | 932 | 179 | 426 | 674 | 923 | 172 | 421 | 672 | 655 | 174 | 426 | 678 | 931 | 184 | 438 | 693 | | 10. |
| | ota | 263 | 263 | 262 | 261 | 260 | 260 | 259 | 258 | 257 | 257 | 256 | 255 | 254 | 254 | 253 | 252 | 251 | 251 | 250 | 249 | | Tang. |
| - | . 1 | 0.1 | 3 1. | 6 1. | 0 1 | 4 1. | 17 1 | 2 | 19 | 111 | 12 | = | 1 9 | 111 | 7 1 | 3 1 | 10 | 5 1 | 2 1 | 9 1 | 6 1 | | |
| | I ang. | 1117 | 164 | 211 | 259 | 306 | 353 | 401 | 448 | 496 | 543 | 591 | 638 | 989 | 1733 | 181 | 828 | 876 | 924 | 1971 | 0119 | | tan |
| 1 | 1 | 37. | 7.79 | 3 -79 | 3 -79 | 34.1 | 37.5 | 1.76 | 37.5 | 37-0 | 31.78 | 37.8 | 37. | 179 | 31-79 | 37. | 3 .79 | 97. | 179 | 1.79 | 980 | | Cosine, Cotang. |
| | Je. | 163 | 3917 | 3616 | 1478 | 375 | 303 | 3314 | 999 | 287 | 514 | 742 | 696 | 1974 | 1248 | 3525 | 1796 | 3901 | 3345 | 5614 | 7882 | | ine. |
| 10 | sine. | 6204 | 620 | 620 | 621 | 621 | 621 | 6218 | 622(| 622 | 622 | 622 | 622 | 623 | 623 | 823(| 833 | 824 | 824 | 524 | 5247 | | Cos |
| 11 0:11 | - | 21 4 | 250 | 23 | 24 | 25 | 98 | 27 | 28 | 68 | 30 | 31 | 35 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 107 | | 11 |
| 1 | | 9 | 59 | 58 | 57 | 56 | 55 | 54 | 53 | 52 | 51 | 50 | 49 | 48 | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 40 | - |
| 1 | ne. | 108 | 316 | 524 | 732 | 939 | 145 | 350 | 555 | 759 | 963 | 165 | 367 | 569 | 770 | 970 | 169 | 368 | 566 | 764 | 196 | 157 | 8. |
| 100 | COSI | 880 | 878 | 876 | 874 | 872 | 871 | 869 | 867 | 865 | 863 | 862 | 860 | 828 | 928 | 854 | 853 | 851 | 849 | 847 | 845 | 844 | Sine. |
| 1 | Cotang. Cosine. | 11.7 | 74.7 | 2. 20 | 11.7 | 7. 8 | 1.7 | 1. 1. | 13 .7 | 2- 00 | 1.12 | 15 .7 | 14 .7 | 3.7 | 3.7 | 3 -7 | 14.7 | 5 .7 | 1. 1. | 7-16 | 2 -7 | 2-9 | |
| 200 | tang | 1994 | 1917 | 1840 | 764 | 687 | 119 | 534 | 458 | 385 | 305 | 229 | 153 | 770 | 001 | 925 | 848 | 773 | 169 | 621 | 546 | 470 | Tang. |
| | | 1.27 | 1.2 | 1.2 | 1.9 | 1.27 | 1.27 | 1.27 | 1.27 | 1.2 | 1.2 | 1.2 | 1.27 | 1.2 | 1.27 | 1.26 | 1.26 | 1.26 | 1.26 | 1.26 | 1.26 | 1.26 | |
| | io | 285 | 754 | 555 | 169 | 191 | 930 | 1001 | 270 | 040 | 210 | 086 | 191 | 922 | 393 | 864 | 336 | 808 | 380 | 752 | \$24 | 282 | ng. |
| /files | Tang. | 781 | 781 | 782 | 782 | 783 | 783 | 784 | 784 | 185 | 785 | 1881 | 786 | 186 | 787 | 787 | 188 | 7881 | 789 | 7897 | 7905 | 190 | ota |
| - | -1 | 15 | . 40 | 86 | - 68 | 80 | - 69 | - 69 | 188 | 36 | 24. | - | 86 | 84 | 10/ | 55 | 39 | 24 | - 10 | 00 | 73 | 55 | Cosine. Cotang. |
| 0 | Sille. | 999 | 589 | 611 | 634 | 857 | 089 | 703 | 726 | 749 | 772 | 195 | 817 | 840 | 863 | 988 | 606 | 935 | 955 | 977 | 000 | 023 | sine |
| - | 9 | .61 | 19. | .61 | .61 | | | -61 | | | | 19. | .61 | .61 | 19. | 19. | .61 | .61 | 19- | .611 | -62 | 20 -6202355 -790697 1-264706 -7844157 40 | Co |
| 1 | 1 | 0 | - | CA | 3 | 4 | 5 | 9 | 7 | œ | 6 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | - |

| - | | 6 | 8 | 7 | 9 | 2 | 4 | 00 | os. | - | 0 | 6 | 00 | 7 | 9 | 2 | 4 | 3 | 63 | - | 0 | 1 | - | - |
|---------|-----------------|---|-------------------------|---|--|--|--|--|--|--|---|---|--|--|---|--|---|--|--|---|---|---|-----------------|----------|
| | osine. | 695853 | 693996 1 | 692137 1 | 690278 | 688418 | 686558 1 | 684697 1 | | 680973 | 679110 1 | 677246 | 675382 | 673517 | 671652 | 689785 | 816299 | 666051 | 664183 | 662314 | 660444 | 1 | Sine. | Deg. 50 |
| | Cotang. Cosine. | -6293204 S09784 1-234897 -777 460 60 21 -6340559 -819948 1-219588 -7732872 3941 -6385440 -829724 1-205219 -7695853 19 | $\frac{629544}{629544}$ | 6297724 8107471 233429 7767797 5823 6345057 820922 1 218142 7729182 3743 6389916 8307071 203793 7692137 | $-6299988 \cdot 811 \cdot 2301 \cdot 532696 \cdot 7765965 \cdot 5724 \cdot 6347305 \cdot 821409 \cdot 7727336 \cdot 3644 \cdot 6392153 \cdot 831199 \cdot 1 \cdot 203081 \cdot 7690278 \cdot 1 \cdot $ | 4302242 811772 1-23 1963 7764132 5625 6349553 821896 1-216698 7725489 3545 6394390 831691 1 202369 7688418 | $6304500 \cdot 812 \cdot 951 \cdot 231231 \cdot 7762298 \cdot 5526 \cdot 6351800 \cdot 822384 \cdot 1 \cdot 215976 \cdot 7723642 \cdot 3446 \cdot 6396626 \cdot 832183 \cdot 201658 \cdot 7686558 \cdot 1201658 \cdot 1201668 \cdot$ | $-6306758 \cdot 8.2678 \cdot 1.230499 \cdot 7760464 \cdot 54.27 \cdot 6354046 \cdot 822871 \cdot 1.215256 \cdot 7721794 \cdot 3347 \cdot 6398862 \cdot 832675 \cdot 1.200947 \cdot 7684697 \cdot 1.200647 \cdot 1.200$ | $-6309015 \cdot 813161 \cdot 229768 \cdot 7758629 \cdot 5328 \cdot 6356292 \cdot 823359 \cdot 1 \cdot 214535 \cdot 7719945 \cdot 3248 \cdot 6401097 \cdot 833168 \cdot 1 \cdot 200237 \cdot 7682835 \cdot 1 \cdot 200237 \cdot 1 \cdot 20027 $ | $6311272 \cdot 813644 \cdot 1.229038 \cdot 7756794 \cdot 5229 \cdot 6358537 \cdot 823847 \cdot 1.213816 \cdot 7718096 \cdot 3149 \cdot 6403332 \cdot 833661 \cdot 1.199527 \cdot 7680973 \cdot 813644 \cdot 1.229038 \cdot 7756794 \cdot 1.22908 \cdot 1.22909 \cdot 1.2$ | -228308 -7754957 51 30 -6360782 -824336 1-213097 -7716246 3050 -6405566 -834154 1-198818 -7679110 | 0.6335784.8146111.227578.77531215031.6363026.8248251.212378.7714395.2951.6407799.8346481.198109.7677246 | $\cdot x_{26849} \cdot 77512834932 \cdot 6365270 \cdot 825314 \cdot 1 \cdot 211660 \cdot 7712544 \cdot 2852 \cdot 6410032 \cdot 835141 \cdot 1 \cdot 197401 \cdot 7675382 \cdot 10888 | $2 \cdot 6320293 \cdot 815580 \cdot 226121 \cdot 7749445 \cdot 48 \cdot 83 \cdot 6367513 \cdot 825803 \cdot 1 \cdot 210942 \cdot 7710692 \cdot 2753 \cdot 6412264 \cdot 835635 \cdot 1 \cdot 96693 \cdot 7673517 \cdot 27710692 \cdot 2753 \cdot 6412264 \cdot 835635 \cdot 1 \cdot 96693 \cdot 7673517 \cdot 27710692 \cdot 2753 \cdot 2753 \cdot 2753 \cdot 27710692 \cdot 2771069$ | $-6322547 \cdot 316064 \cdot 1\cdot 225393 \cdot 7747606 \cdot 47 \cdot 34 \cdot 6369756 \cdot 826292 \cdot 1\cdot 210225 \cdot 7708840 \cdot 2654 \cdot 6414496 \cdot 836129 \cdot 1\cdot 195986 \cdot 7671652 \cdot 100000000000000000000000000000000000$ | $-6324800 \cdot 816549 \cdot 1.224665 \cdot 7745767 \cdot 46 \cdot 35 \cdot 6371998 \cdot 826782 \cdot 1.209508 \cdot 7706986 \cdot 25 \cdot 55 \cdot 6416728 \cdot 836624 \cdot 1.195279 \cdot 7669785 \cdot 6324800 \cdot 816549 \cdot 7669785 \cdot 6416728 \cdot 836624 \cdot 1.195279 \cdot 7669785 \cdot 1.196785 \cdot 1.19$ | 5.6327053.8170341.223938.7743926[45]36.6374240.8272711.208792.7705132.24[56].6418958.837118[1.194573].7667918 | $6.6329336.917519\ 1.223212\ -7742086\ 4437\ -6376481\ -827762\ 1.208076\ -7703278\ 2357\ -6421189\ -837613\ 1.193867\ -7666051$ | $\cdot 6331557 \cdot 818004 \cdot 1 \cdot 222486 \cdot 7740244 \cdot 43188 \cdot 6378721 \cdot 828252 \cdot 1 \cdot 207361 \cdot 7701423 \cdot 2258 \cdot 6423418 \cdot 838108 \cdot 1 \cdot 193162 \cdot 7664183 \cdot 1088168 \cdot 1$ | 828742 1.206646 7699567 21 59 6425647 838604 1.192457 7662314 | $9.6336059 \cdot 818976 \cdot 1.221036 \cdot 7736559 \cdot 4110 \cdot 6383201 \cdot 829233 \cdot 1.205932 \cdot 7697710 \cdot 2060 \cdot 6427876 \cdot 839099 \cdot 1.191753 \cdot 7660444$ | 1 | Tang. | |
| | Tang. | 829724 | 830216 1 | 830707 1 | 831199 1 | 831691 1 | 832183 1 | 832675 1 | 833168 1 | 833661 1 | 834154 1 | 834648 1 | 835141 1 | 835635 1 | 836129 1 | 836624 1 | 837118 1 | 837613 1 | 838108 1 | 838604 1 | -839099 1 | | Cotang. | |
| 39 Deg. | Sine. | 6385440 | 6387678 | -6389916 | 6392153 | 6394390 | 9299689 | -6398862 | 6401097 | -6403332 | -6405566 | 6407799 | -6410032 | 6412264 | 6414496 | -6416728 | 6418958 | 6421189 | 6423418 | 6425647 | -6427876 | | Cosine. Cotang. | |
| 33 | 11 | 19 41 | 88 42 | 8743 | 8644 | 35 45 | 94 46 | 13 47 | 82 48 | 1149 | 09 09 | 196 | 852 | 17 53 | 6 54 | 55 55 | 24 56 | 3 57 | 22 58 | 11 59 | 09 02 | | 111 | 50. |
| | Cosine. | 7732872 | 7731027 | 7729182 | 7727336 | 7725489 | 7723642 | 7721794 | 7719945 | 7718096 | 7716246 | 7714395 | 7712544 | 7710692 | 7708840 | 7706986 | 7705132 | 7703278 | 7701423 | 7699567 | 7697710 | 1 | Sine. | Deg. 50. |
| | Tang. Cotang. | -219588 | 1.218865 | 1-218142 | 1.217419 | -216698 | 1.215976 | 1-215256 | 1-214535 | 1.213816 | -213097 | .212378 | .211660 | .210942 | 1-210225 | 809602 | 1.208792 | 920802- | 1-207361 | 1-206646 | 1.205932 | - | Tang. | |
| | Tang. | 819948 | 820435 | 820922 | 821409 | 821896 | 822384 | 822871 | 823359 | 823847 | 824336 | 824825 | 825314 1 | 825803 1 | 826292 | 826782 | 827271 | 827762 | 828252 | 828742 | 826233 | | Cotang. | |
| 39 Deg. | Sine. | 6340559 | 6342808 | 6345057 | 6347305 | 6349553 | 6351800 | 6354046 | 6356292 | 6358537 | 6360782 | 6363026 | 6365270 | 6367513 | 6369756 | 6371998 | 6374240 | 6376481 | 6378721 | 6380961 | 6383201 | - | Cosine. | |
| 39 | _ | 0 21 | 9 22 | 8 23 | 7 24 | 625 | 526 | 127 | 888 | 2 29 | 1 30 | 31 | 932 | 333 | 7 34 | 8 35 | 5 36 | 137 | 388 | 2 39 | 01 10 | 0 | 1 | |
| | Cosine. | 7771460 6 | 77696295 | 7767797 5 | 7765965 5 | 7764132 5 | 7762298 5 | 7760464 5 | 7758629 5 | 7756794 5 | 7754957 5 | 7753121 5 | 7751283 4 | 7749445 4 | 77476064 | 7745767 4 | 7743926 4 | 7742086 4 | 7740244 4 | 8 6333809 818490 1 221761 7738402 42 39 6380961 | 7736559 4 | 20-6338310 -819462 1-220312 -7734716 40 | Sine. | Deg. 50. |
| | Cotang. | -234897 | -234162 | 233429 | -232696 | -231963 -7 | -231231 | -230499 | -229768 | -229038 | -228308 | .227578 | -226849 | ·226121 ·7 | .225393 | 224665 | -923938 | -223212 | -222486 | -2217611-7 | -221036 | .278022- | Tang. | |
| | Tang. | 809784 | 810265 | 810747 | 811230 | 811712 | 8121951 | 812678 | 813161 | 813644 | 814128 | 814611 | 815095 | 815580 | 816064 | 816549 | 817034 | 817519 | -818004 | 818490 | 818976 | -819462 | Cotang. | 1 |
| Jeg. | Sine. | 6293204 | 6295464 | 6297724 | 6299983 | 6302242 | 6304500 | 6306758 | 6309015 | 6311272 | -6313528 -814128 | 6315784 | 6318039 815095 | 6320293 | 6322547 | 6324800 | 6327053 | 6329306 | 6331557 | 6333809 | 6336059 | 6338310 | Cosine. Cotang. | |
| 39 Deg. | - | 10 | - | . 64 | 3 | 4 | 10 | 9 | 1 | œ | 6 | 10 | - | 12 | 13 | 14 | 12 | 16 | 17 | 18 | 9 | 52 | 1- | 7 |

Deg. 49.

| 40 Deg. | | | | | | | | | | | | - | | - | | - | - | - | , | | | | | |
|--|------|---------|------------|------------|------------|------------|-------------|------------|------------|-------------|------------|------------|-------------|------------|-------------|-------------|-------------|------------|------------|------------|------------|------------|------------|---------|
| 6. 8876 1104 1104 1104 1104 1104 1106 1106 110 | | F | 10 | 000 | 20 | 16 | 15 | | 13 | 12 | 11 | 10 | 6 | 00 | 7 | 9 | LC. | ¥ | 00 | 6 | E | 0 | | 1- |
| 6. 8876 1104 1104 1104 1104 1104 1106 1106 110 | | Cosine. | 7583240 | 7581343 | -7579446 | .7577548 | .7575650 | 7573751 | 7571851 | .7569951 | .7568050 | .7566148 | -7564246 | -7562343 | -7560439 | 7558535 | .7556630 | 7554724 | .7552818 | -7550911 | -7549004 | 7547096 | | Sine. |
| 6. 8876 1104 1104 1104 1104 1104 1113 1116 1116 1116 1116 1116 | | Cotang. | 1-163291 | 1-162607 | 1-161923 | 1-161240 | 1-160557 | 1-159874 | 1-159192 | 1.158511 | 1-157830 | 1-157149 | 1-156469 | 1-155789 | 1-155110 | 1-154431 | 1-153753 | 1-153075 | 1-152397 | 1-151721 | 1-151044 | 1.150368 | | Tang. |
| 6. 8876 1104 1104 1104 1104 1104 1113 1116 1116 1116 1116 1116 | | Tang. | 859629 | 860135 | -860641 | 861148 | -861655 | 862162 | 862669 | 863176 | -863684 | 864192 | 864700 | 865209 | 865718 | -866227 | -866736 | 867246 | 867755 | -868265 | 921898 | 869286 | | Cotang. |
| 6. 8876 1104 1104 1104 1104 1104 1113 1116 1116 1116 1116 1116 | Deg. | Sine. | 6518778 | 6520984 | 6523189 | 6525394 | 6527598 | 6529801 | 6532004 | 6534206 | 6536408 | 6538609 | 6540810 | 6543010 | 6545209 | 6547408 | 6549607 | 6551804 | 6554002 | 6556198 | 6558395 | 6560590 | | Cosine. |
| 6. 8876 1104 1104 1104 1104 1132 1132 1132 1132 1132 1116 1116 1116 | 40 | - | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 20 | 51 | 52 | 53 | 55 | 55 | 99 | 57 | 58 | 59 | 09 | | 1- |
| 6. 8876 1104 1104 1104 1104 1104 1113 1116 1116 1116 1116 1116 | | - | 39 | 38 | 37 | 36 | 35 | 34 | 33 | 32 | 31 | 30 | 29 | 28 | 127 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | | 1 |
| 6. 8876 1104 1104 1104 1104 1104 1132 1132 1132 1132 1132 1132 1132 113 | | Cosine. | -7621036 | 7619152 | .7617268 | -7615383 | 7613497 | 7611611 | -7609724 | .7607837 | ·7605949 | -7604060 | .7602170 | .7600280 | ·7598389 | -7596498 | -7594606 | -7592713 | .7590820 | .7588926 | -7587031 | 7585136 | | Sine. |
| 6. 8876 1104 1104 1104 1104 1104 1113 1116 1116 1116 1116 1116 | | Cotang. | 1-177075 | 1-176382 | 1.175688 | 1-174996 | 1-174303 | 1-173612 | 1-172920 | 1-172229 | 1-171539 | 1-170849 | 1-170160 | 1-169471 | 1-168782 | 1-168094 | 1-167407 | 1-166720 | 1-166033 | 1-165347 | 1-164661 | 1-163976 | | |
| 6. 8876 1104 1104 1104 1104 1104 1113 1116 1116 1116 1116 1116 | | Tang. | 849563 | 850064 | 850565 | 851066 | 892128 | -852070 | 852572 | 853075 | 853577 | 854080 | 854583 | -855087 | 855591 | 856095 | 856599 | 857103 | 827608 | 858113 | 819898 | 859124 | | Cotang. |
| 6. 8876 1104 1104 1104 1104 1104 1113 1116 1116 1116 1116 1116 | Deg. | Sine. | 6474551 | 6476767 | 6478984 | 6481199 | 6483414 | 6485628 | 6487842 | 6490056 | 6492268 | 6494480 | 6496692 | 6498903 | 6501114 | 6503324 | 6505533 | 6507742 | 6509951 | 6512158 | 6514366 | 6516572 | | Cosine. |
| 6. 8876 1104 1104 1104 1104 1104 1113 1116 1116 1116 1116 1116 | 40 | _ | 12 | 22 | 23 | 24 | 52 | 56 | 27 | 28 | 53 | 30 | 31 | 35 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 0 | |
| 6. 8876 1104 1104 1104 1104 1104 1132 1132 1132 1132 1132 1132 1132 113 | | Cosine. | 7660444 60 | 7658574 59 | 7656704 58 | 7654832 57 | -7652960 56 | 7651087 55 | 7649214 54 | -7647340 53 | 7645465 55 | 7643590 51 | .7641714 50 | 7639838 45 | .7637960 48 | -7636082 47 | -7634204 46 | 7632325 45 | 7630445 44 | 7628564 43 | 7626683 42 | 7624802 41 | 7622919 40 | |
| 6. 8876 1104 1104 1104 1104 1104 1132 1132 1132 1132 1132 1132 1132 113 | | | 1-191753 | 1-191049 | 1.190346 | 1.189643 | 1-188941 | 1.188239 | 1-187538 | 1-186837 | 1.186136 | 1.185437 | 1.184737 | 1.184038 | 1.183340 | 1.182642 | 1-181944 | 1-181247 | 1-180551 | 1-179855 | | 1-178464 | 1.177769 | |
| 6. 8876 1104 1104 1104 1104 1104 1132 1132 1132 1132 1132 1132 1132 113 | | Tang. | 839099 | 839595 | 1.840091 | 840587 | -841084 | -841581 | 842078 | -842575 | 843073 | 843570 | .844068 | -844567 | -845065 | 1-845564 | 846063 | 846562 | -847062 | 847561 | 848061 | -848561 | 849062 | Cotang. |
| 6 - 101884666748601 | Deg. | Sine. | 6427876 | -6430104 | 6432332 | 6434559 | 6436785 | 6439011 | 6441236 | -6443461 | 6445685 | -6447909 | -6450132 | -6452355 | 6454577 | 6456798 | 6459019 | -6461240 | -6463460 | 6465679 | 6467898 | -6470116 | 6472334 | Cosine. |
| | 0\$ | - 1 | 0 | - | 01 | 8 | | | | | | | 10 | = | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 18 | 20 | - |

| | | | *** | | 100 | | • | - | - | - | , | - | | | - | - | 200 | | | - | | | | - |
|---------|---------|--|---|--|--|--|---|---|--|---|--|--|--|--|--|---|---|--|--|--|---|--|-------------------|----------|
| E | | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | Ξ | 10 | 6 | 00 | 7 | 9 | 5 | 4 | 3 | CH | 1 | 0 | | 1- | 18 |
| Coning | Cosine. | -7468317 | 1-122375 -7466382 | 7464446 | .7462510 | -7460574 | .7458636 | -7456699 | -7454760 | -7452821 | 7450881 | 7448941 | -7446999 | 7445058 | 7443115 | -7441173 | .7439229 | .7437285 | .7435340 | •7433394 | 7431448 | | Sine. | Deg. 48 |
| Cotono | Cotang. | 1-123032 | 1-122375 | 1-121718 | 1.121061 | 1.120405 | 1-119749 | 1.119094 | 1.118439 | 1.117784 | 1-117130 | 1-116476 | 1-115823 | 1-115170 | 1.114518 | 1-113866 | 1-113214 | 1-112563 | 1-111912 | 1-111262 | 1-110612 | | Tang. | |
| Thomas | rang. | 890445 | 196068 | 891489 | -892011 | 892534 | 893056 | 893579 | 894103 | .894626 | 895150 | 895674 | 896199 | -896723 | 897248 | 897773 | 898299 | 898825 | 899351 | 899877 | -900404 | | Cotang. | |
| 41 Deg. | eame. | 6650131 | 6652304 | 6654475 | 6656646 | 6658817 | 2860999 | 9912999 | 6665325 | 6667493 | 1996999 | 6671828 | 6673994 | 6676160 | 6678326 | 6680490 | 6682655 | 6684818 | 1869899 | 6689144 | 6691306 | | / Cosine. Cotang. | |
| 41 | j | 941 | 842 | 743 | 644 | 545 | 446 | 347 | 248 | 149 | 0 20 | 951 | 8 52 | 7 53 | 654 | 5 55 | 4 56 | 357 | 2 58 | 1 69 | 09 0 | | - | - |
| Commo | Cosme | $\cdot 6560590 \cdot 869286 \cdot 1 \cdot 150368 \cdot 7547096 \cdot 8021 \cdot 6606570 \cdot 880068 \cdot 1 \cdot 136274 \cdot 7506879 \cdot 3941 \cdot 6650131 \cdot 890445 \cdot 1 \cdot 123032 \cdot 7468317 \cdot 1968317 \cdot 19$ | $6562785 \cdot 869797 \cdot 1 \cdot 149692 \cdot 7545187 \cdot 5922 \cdot 6608754 \cdot 880585 \cdot 1 \cdot 135608 \cdot 7504957 \cdot 3842 \cdot 6652304 \cdot 890967 \cdot 100000000000000000000000000000000000$ | $\cdot 6564980 \cdot 870308 \cdot 149017 \cdot 7543278 \cdot 5823 \cdot 6610936 \cdot 881101 \cdot 1134942 \cdot 7503034 \cdot 13743 \cdot 6654475 \cdot 891489 \cdot 1121718 \cdot 7464446 \cdot 12718 \cdot 746446 \cdot 12718 $ | $\cdot 6567174 \cdot 870820 \cdot 1 \cdot 148342 \cdot 7541368 \cdot 5724 \cdot 6613119 \cdot 881618 \cdot 1 \cdot 134277 \cdot 7501111 \cdot 3644 \cdot 6656646 \cdot 892011 \cdot 1 \cdot 121061 \cdot 7462510 \cdot 66567174 \cdot 6656719 \cdot 665719 \cdot 66571$ | $\cdot 6569367 \cdot 871331 \cdot 1 \cdot 147668 \cdot 7539457 \cdot 56 25 \cdot 6615300 \cdot 882135 \cdot 1 \cdot 133612 \cdot 7499187 \cdot 35 45 \cdot 6658817 \cdot 892534 \cdot 1 \cdot 120405 \cdot 7460574 \cdot 74$ | $\cdot 6571560 \cdot 871843 \cdot 1 \cdot 146994 \cdot 7537546 \cdot 6526 \cdot 6617482 \cdot 882663 \cdot 1 \cdot 132947 \cdot 7497262 \cdot 3446 \cdot 6660987 \cdot 893056 \cdot 1 \cdot 119749 \cdot 7458636 \cdot 6571560 \cdot 871843 \cdot 1 \cdot $ | $\cdot 6573762 \cdot 872355 \cdot 1 \cdot 146321 \cdot 7535634 \cdot 5427 \cdot 6619662 \cdot 883170 \cdot 1 \cdot 132283 \cdot 7495337 \cdot 3347 \cdot 6663156 \cdot 893579 \cdot 1 \cdot 119994 \cdot 7456699$ | $\cdot 6575944 \cdot 872868 \cdot 1 \cdot 145648 \cdot 7533721 \cdot 5328 \cdot 6621842 \cdot 883688 \cdot 1 \cdot 131620 \cdot 7493411 \cdot 3248 \cdot 6665325 \cdot 894103 \cdot 1 \cdot 118439 \cdot 7454760 \cdot 6575944 \cdot 872868 \cdot 1 \cdot 145648 \cdot 753721 \cdot 118439 \cdot 7454760 \cdot 7493411 \cdot 118439 \cdot 749411 \cdot 749411 \cdot 118439 \cdot 749411 \cdot 118449 \cdot 749411 \cdot$ | $\cdot 6578135 \cdot 873380 \cdot 1 \cdot 144976 \cdot 7531808 \cdot 5229 \cdot 6624022 \cdot 884206 \cdot 1 \cdot 130957 \cdot 7491484 \cdot 3149 \cdot 6667493 \cdot 894626 \cdot 1 \cdot 117784 \cdot 7452821 \cdot 1 \cdot$ | $\cdot 6580326 \cdot 873893 \cdot 1.144304 \cdot 7529894 \cdot 5130 \cdot 6626200 \cdot 884725 \cdot 1.130294 \cdot 7489557 \cdot 3050 \cdot 6669661 \cdot 895150 \cdot 1.17130 \cdot 7450881 \cdot 7450881 \cdot 7460881 \cdot 746081 \cdot 7$ | $\cdot 6582516 \cdot 874406 \cdot 1.143632 \cdot 7527980 \cdot 5031 \cdot 6628379 \cdot 885244 \cdot 1.129632 \cdot 7487629 \cdot 29 \cdot 51 \cdot 6671828 \cdot 895674 \cdot 1.116476 \cdot 744894 \cdot 1.1164$ | $\cdot 6584706 \cdot 874920 \cdot 1.142961 \cdot 7526065 \cdot 49 \cdot 32 \cdot 6630557 \cdot 885763 \cdot 1.128970 \cdot 7485701 \cdot 2852 \cdot 6673994 \cdot 896199 \cdot 1.115823 \cdot 7446999 \cdot 1.116823 \cdot 1.$ | $\cdot 6586895 \cdot 875433 \cdot 1 \cdot 142290 \cdot 7524149 \cdot 48 \cdot 33 \cdot 6632734 \cdot 886282 \cdot 1 \cdot 128308 \cdot 7483772 \cdot 27 \cdot 53 \cdot 6676160 \cdot 896723 \cdot 1 \cdot 115170 \cdot 7445058 \cdot 7483772 \cdot 27 \cdot 53 \cdot 6676160 \cdot 896723 \cdot 1 \cdot 115170 \cdot 7445058 \cdot 7483772 \cdot 27 \cdot 53 \cdot 6676160 \cdot 896723 \cdot 1 \cdot 115170 \cdot 7445058 \cdot 7483772 \cdot 27 \cdot 53 \cdot 6676160 \cdot 896723 \cdot 1 \cdot 115170 \cdot 7445058 \cdot 7483772 \cdot 27 \cdot 53 \cdot 6676160 \cdot 896723 \cdot 1 \cdot 115170 \cdot 7445058 \cdot 7483772 \cdot 27 \cdot 53 \cdot 6676160 \cdot 896723 \cdot 7483772 \cdot 27 \cdot 53 \cdot 6676160 \cdot 896723 \cdot 7483772 \cdot 27 \cdot 53 \cdot 67 \cdot 67 \cdot 67 \cdot 77 \cdot 77 \cdot 77 \cdot 77 \cdot 7$ | $\cdot 6589083 \cdot 875947 \cdot 1 \cdot 141620 \cdot 7522233 \cdot 4734 \cdot 6634910 \cdot 886801 \cdot 1 \cdot 127647 \cdot 7481842 \cdot 2654 \cdot 6678326 \cdot 897248 \cdot 1 \cdot 114518 \cdot 7443115 \cdot 7443115 \cdot 7481842 \cdot 26549 \cdot 1041620 \cdot 75246 \cdot 7481847 \cdot 748187 \cdot 7481847 \cdot 748187 \cdot 7481$ | $\cdot 6591271 \cdot 876462 \cdot 1 \cdot 140950 \cdot 7520316 \cdot 4635 \cdot 6637087 \cdot 887321 \cdot 1 \cdot 126987 \cdot 7479912 \cdot 25 \cdot 55 \cdot 6680490 \cdot 897773 \cdot 1 \cdot 113866 \cdot 7441173 \cdot 1 \cdot $ | $\cdot 6593458 \cdot 876976 \cdot 1 \cdot 140281 \cdot 7518398 \cdot 45 \cdot 36 \cdot 6639262 \cdot 887841 \cdot 1 \cdot 126327 \cdot 7477981 \cdot 2456 \cdot 6682655 \cdot 898299 \cdot 1 \cdot 13214 \cdot 7439229 \cdot 1 \cdot 126327 \cdot 1 \cdot $ | $\cdot 6595645 \cdot 877491 \cdot 1 \cdot 139612 \cdot 7516480 \cdot 44 \cdot 37 \cdot 6641437 \cdot 888361 \cdot 1 \cdot 125667 \cdot 7476049 \cdot 23 \cdot 57 \cdot 6684818 \cdot 898825 \cdot 1 \cdot 112563 \cdot 7437285 \cdot 123648 | $\cdot 6597831 \cdot 878006 \cdot 1 \cdot 138944 \cdot 751456 \cdot 14338 \cdot 66436 \cdot 1288882 \cdot 1 \cdot 125008 \cdot 7474117 \cdot 2258 \cdot 668698 \cdot 899351 \cdot 1111912 \cdot 7435340 \cdot 6597831 \cdot 888882 \cdot 1 \cdot 111912 \cdot 7435340 \cdot 7474117 \cdot 12258 \cdot 668698 \cdot 12268 $ | $\cdot 6600017 \cdot 878521 \cdot 1 \cdot 138276 \cdot 7512641 \cdot 4239 \cdot 6645785 \cdot 889403 \cdot 1 \cdot 124349 \cdot 7472184 \cdot 2159 \cdot 6689144 \cdot 899877 \cdot 1 \cdot 111262 \cdot 7433394 \cdot 111262 \cdot 7433394 \cdot 111262 \cdot 7433394 \cdot 111262 \cdot 7433394 \cdot 1111262 \cdot 7433394 \cdot 1111262 \cdot 7433394 \cdot 11111111111111111111111111111111111$ | $\cdot 6602202 \cdot 879037 \cdot 1 \cdot 137608 \cdot 7510721 \cdot 141 \cdot 140 \cdot 6647959 \cdot 889924 \cdot 1 \cdot 123690 \cdot 7470251 \cdot 20 \cdot 609 \cdot 6691306 \cdot 90 \cdot 404 \cdot 1 \cdot 110612 \cdot 7431248 \cdot 100000000000000000000000000000000000$ | | Sine, | Deg. 48. |
| Cotone | Cotang. | 1-136274 | 1.135608 | 1-134942 | 1-134277 | 1-133612 | 1.132947 | 1.132283 | 1.131620 | 1-130957 | 1.130294 | 1-129632 | 1-128970 | 1.128308 | 1.127647 | 1.126987 | 1.126327 | 1-125667 | 1-125008 | 1.124349 | 1.123690 | | Tang. | |
| Tong | rang. | 890088 | 880282 | 101188 | 881618 | 882132 | 882653 | 883170 | 883688 | 884206 | 884725 | 885244 | 885763 | 886282 | 108988 | 887321 | 887841 | 198888 | 888888 | 889403 | 889924 | | Cotang. | |
| 41 Deg. | ome. | 6606570 | 6608754 | 6610936 | 6613119 | 6615300 | 6617482 | 6619662 | 6621842 | 6624022 | 6626200 | 6628379 | 6630557 | 6632734 | 6634910 | 6637087 | 6639262 | 6641437 | 6643612 | 6645785 | 6647959 | | Cosine. Cotang. | |
| 41 | | 021 | 922 | 8 23 | 724 | 625 | 526 | 427 | 3 28 | 2 29 | 130 | 031 | 932 | 833 | 7 34 | 635 | 536 | 437 | 338 | 2 39 | 140 | 0 | - | |
| - Cuino | Cosme. | 7547096 | 7545187 5 | 7543278 5 | 7541368 5 | 7539457 5 | 7537546 5 | 7535634 5 | 7533721 5 | 7531808 5 | 7529894 5 | 7527980 5 | 7526065 4 | 75241494 | 7522233 | 7520316 | 7518398 | 75164804 | 7514561 4 | 7512641 4 | 7510721 4 | 20 -6604386 -879552 1-136941 -7508800 40 | Sine. | Deg. 48 |
| Cotono | Cotang. | 1-150368 | 1-149692 | 1.149017 | 1.148342 | 1.147668 | 1.146994 | 1.146321 | 1-145648 | 1-144976 | 1-144304 | 1-143632 | 1-142961 | 1-142290 | 1-141620 | 1-140950 | 1-140281 | 1-139612 | 1-138944 | 1-138276 | 1-137608 | 1-136941 | Tang. | |
| | Tang. | 982698 | 126698 | 808018 | 870820 | 871331 | 871843 | 872355 | 812868 | 873380 | 873893 | 874406 | .874920 | 875433 | 875947 | 876462 | 876976 | 877491 | 900878 | 878521 | 879037 | 879552 | Cotang. | |
| 41 Deg. | oille. | 6560590 | 6562785 | 6564980 | 6567174 | 6569367 | 6571560 | 6573752 | 6575944 | 6578135 | 6580326 | 6582516 | 6584706 | 6586895 | 6589083 | 6591271 | 6593458 | 6595645 | 6597831 | 6600017 | 6602202 | 6604386 | Cosine. | |
| - | 1 | 0 | 1 | es | 3 | 4 | 2 | 9 | - | œ | 6 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 02 | 1- | |

NATURAL SINES AND TANGENTS TO A RADIUS 1.

| 1 | | 007-004-601-000-004-601-0 | _ | 17. |
|---------|-----------|---|------------------|----------------|
| * | Cosine- | | Sine. | Deg. 47. |
| | Cotang. C | 1.084322 7351118 1.083689 -7349146 1.083689 -7349146 1.081169 7734773 1.081169 77341225 1.079901 7737399 1.079901 7737399 1.078013 77333345 1.078013 7733345 1.076756 77327409 1.075128 77323449 1.075294 7731466 1.075294 7731466 | Tang. | |
| | Tang. | 922235 1 9222773 9223773 9223773 922351 922451 9226470 926010 9226550 9226550 922657 922773 92 | Cotang. | |
| 42 Deg. | Sine. | 6779159 6783734 678571 6788007 67990143 6792278 6794113 6796547 6796547 6800818 6800818 6800818 6800818 6807209 68135728 68135728 68135728 | Cosine. Cotang. | |
| 42 | - | 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | | - |
| | Cosine. | 21 | Sine, | Doc 47 |
| | Cotang. | 1.097060 1.095779 1.095779 1.095139 1.097281 1.097281 1.097281 1.097281 1.097281 1.097398 1.088762 1.0 | Tang. | |
| | Tang. | 911526 912659 913259 913125 914192 914727 915261 915261 915261 91531 916331 917427 919477 919474 919547 919547 919547 919547 | Cotang. | - |
| 42 Deg. | Sine. | 6736577 6740876 67410876 6745172 6745161 6745161 67551612 6755902 6755903 676618 676618 676618 6773041 6773041 | Cosine. Cotang. | |
| 42 | = | 0.00 % K 5 9 4 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 | ` | 1, |
| | Cosine. / | 6691306 900440 1-110612 7431448 60 21 6736577 911526 1-097060 7380435 3941 6779459 9022773 1083689 7349446 6693468 900930 1-1109612 7421502 5922673 695426 7384946 6693468 900930 1-109963 7424707 1083689 7349146 6693688 900930 1-109963 7422502 583 6740872 900930 108361 922773 1083689 7349446 92779 108369 922773 108368 922773 108368 922773 108368 6626 744770 900946 73845533 3614 678607 92491 108378 900946 7384566 9347 74770 900946 737473 900946 737473 900946 737473 900946 737473 900946 900946 900097 900946 900097 900946 900097 900946 900097 900966 900097 900967 900097 900097 900097 900097 <td< td=""><td>Sine.</td><td>100</td></td<> | Sine. | 100 |
| | Cotang. | 1-110612 1-109963 1-109314 1-108017 1-106721 1-106721 1-106721 1-106721 1-106721 1-106721 1-106721 1-106721 1-106721 1-106721 1-106721 1-1068985 1-098985 1-098985 1-098343 | Tang. | |
| | Tang. | 900404 900404 901985 901985 902513 904097 904087 904087 904087 907274 907805 909939 909939 909939 | Cotang. | 0 |
| 42 Deg. | Sine. | 6691306 6693468 6693468 6693468 669948 669948 6702108 6702208 6702208 670622 671209 671209 671209 671209 671209 671209 671209 6721505 671209 6721515 6721515 6721515 6722681 672368 673302 67 | Cosine Cotang. | - Constitution |
| 53 | 1 | 0-8840878801111111111111111111111111111111 | 1- | 1 |

| - | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 6 | 00 | 7 | 9 | 2 | 7 | 3 | C.S | - | 0 | 1 | - | 46 |
|-----------------|----------|---|--|--|--|--|--|---|--|---|--|---|--|---|--|--|---|---|---|--|----------------------|---------------------|---------|
| Cosine. | | 7229671 | 7227661 | 7225651 | 7223640 | 7221628 | 7219615 | 7217602 | 7215589 | 7213574 | 7211559 | 7209544 | 7207528 | 7205511 | 7203494 | 7201476 | 7199457 | 7197438 | 7195418 | -7193398 | | Sine. | For. 46 |
| Cotang. | | D813984 53231 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 | $\frac{1.058086 \cdot 7267745}{6894097 \cdot 93686} \cdot \frac{1.058086 \cdot 7267745}{68886} \cdot \frac{1.058086 \cdot 7267745}{68896} \cdot \frac{1.058086 \cdot 726774}{68896} \cdot 1.$ | $\frac{1}{6896368}, \frac{1}{631147}, \frac{1}{1070494}, \frac{1}{7307583}, \frac{1}{5724}, \frac{1}{6870875}, \frac{1}{945653}, \frac{1}{687067}, \frac{1}{7265747}, \frac{1}{3644}, \frac{1}{6913029}, \frac{1}{956734}, \frac{1}{1045232}, \frac{1}{7225651}, \frac{1}{1045632}, | $\frac{1}{6823480}, \frac{1}{069870}, \frac{1}{069870}, \frac{1}{069870}, \frac{1}{06980}, \frac{1}{06880}, \frac{1}{06880}$ | $\frac{1}{2} \frac{1}{2} \frac{1}{3} \frac{1}$ | $\frac{1}{6899778}, \frac{1}{985783}, \frac{1}{1068623}, \frac{1}{7301623}, \frac{1}{627}, \frac{6877213}{68997807}, \frac{1}{1055623}, \frac{1}{7259748}, \frac{1}{3347}, \frac{1}{6919332}, \frac{1}{958407}, \frac{1}{11043397}, \frac{1}{7219615}, \frac{1}{11043397}, \frac{1}{11043$ | $\frac{1.055008 \cdot 7257747}{683466} \cdot \frac{1.058000 \cdot 7299635}{10000} \cdot \frac{1.055008 \cdot 7257747}{10000} \cdot \frac{1.055008 \cdot 7257747}{100000} \cdot \frac{1.055008 \cdot 7257747}{1000000000000000000000000000000000000$ | $\frac{6836684}{6836684}, \frac{936875}{968875} \left[\frac{1067377}{7229646}, \frac{7259746}{58269} \right] \cdot \frac{9581435}{96881435}, \frac{9484111}{964394}, \frac{7255746}{7255746} \right] \cdot \frac{49}{8923531} \cdot \frac{95924}{95924} \cdot \frac{1042183}{7215589}, \frac{1042183}{96826}, \frac{10421}{96826}, \frac{10421}{96826}, \frac{10421}{96826}, \frac{10421}{96826}, $ | $\frac{6839107 + 93742}{93742} \ \frac{1066755}{966755} - \frac{7295657}{968756} \ \frac{1083964}{9698263} \ \frac{1053780}{9698263} \ \frac{7253744}{96982} \ \frac{106755}{9698263} \ \frac{1041576}{9698263} | -6441299 + 9379681 + 066134 + 729366815031 + 6885655 + 949517 + 1053166 + 7251741 + 2951 + 6927728 + 360642 + 1040970 + 7211559 + 1040970 + 1040 | 52 6929825 961201 1.040364 7209544 | 2.6845471 -93062 1 064891 7289686 48 33 -6889973 950624 1 051940 7247734 27 53 6931922 961761 1 039758 7207528 | $3.6845591.939610 \\ 1.0642711.7287695614734.68919811.951178 \\ 1.051327.7245729 \\ 26654.6934018.962321 \\ 1.039153.7205511 \\ 1.051327.7245729 \\ 1.05127.7245729 \\ 1.051327.7245729 \\ 1.05127.72457$ | $\frac{6849711}{940157} + \frac{940157}{940157} + \frac{63851}{940157} + \frac{7285703}{940157} + \frac{6857}{940157} + \frac{103854}{940157} + 103$ | $\begin{array}{cccccccccccccccccccccccccccccccccccc$ | $6.6858948 \cdot 94.1254 \cdot 1.0624 \cdot 11.728 \cdot 1716 \cdot 4437 \cdot 6898302 \cdot 952842 \cdot 1.049492 \cdot 7239712 \cdot 2357 \cdot 6940304 \cdot 964003 \cdot 1.037340 \cdot 7.099457$ | .6856666 -941803 1 -111. 792 -7279722 43 38 -6900407 -953397 1-048880 -7237705 22 58 -6942399 -964565 1-036736 -7197438 | $8.6888184 \cdot 942352.1 \cdot 061174 \cdot 72777281423916902512 \cdot 9539521 \cdot 048270 \cdot 7235698159 \cdot 6944491 \cdot 9651261 \cdot 036133 \cdot 7195418$ | 40 6904617 954508 1.047659 7233690 20 60 6946584 965688 1.035530 7193398 | | Tang. | |
| Tang. | 955064 | 955620 | 956177 | 956734 | 162766 | 957849 | 958407 | 9589651 | -959524 | -960082 | -960642 | 108196- | 192196 | 962321 | 188596 | 963442 | .964003 | -964565 | 962126 | -965688 | | Cotang. | |
| Sine. | 6906721 | 6908824 | 6910927 | 6313029 | 6915131 | 6917232 | 6919332 | 6921432 | 6923531 | 6925630 | 6927728 | 6929825 | 6931922 | 6934018 | 6936114 | 6038869 | 6940304 | 6942398 | 6944491 | 6946584 | | Cosine, Cotang. | |
| - | 1 = | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | . 22 | 99 | 57 | 58 | - 69 | .109 | | 11 | |
| - | 0 39 | 3 38 | 5 37 | 7 36 | 8 35 | 8 34 | 8 33 | 7 32 | 6 31 | 4 30 | 1 29 | 8 28 | 4 27 | 926 | 4 25 | 9 24 | 2 23 | 6 22 | 8 21 | 0 20 | | | 40 |
| Cosine. | -727174 | .726974 | .726774 | -726574 | -726374 | -726174 | -725974 | -725774 | -725574 | -725374 | 725174 | .724973 | .724773 | -724572 | -724372 | 724171 | -723971 | .723770 | -723569 | .723369 | | Sine. | 11. 40 |
| Tang. Cotang. | 1.059320 | 1.058703 | 1.058086 | 1-057470 | 1.056854 | 1-056238 | 1-055623 | 1.055008 | 1.054394 | 1.053780 | 1-053166 | 1-052553 | 1.051940 | 1-051327 | 1-050715 | 1-050103 | 1-049492 | 1-048880 | 1-048270 | 1-047659 | | Tang. | |
| Tang. | 944001 | 944551 | 945102 | 945653 | 946204 | 946755 | 947307 | 947859 | 948411 | 948964 | 949517 | 950070 | 950624 | 951178 | 951732 | 95228711 | 952842 | 953397 | 953952 | 954508 | | Cotang. | 1 |
| Sine. | 6864539 | 6866647 | 1928989 | 6870875 | 6872988 | 6875101 | 6877213 | 6879325 | 6881435 | 6883546 | 6885655 | 6887765 | 6889873 | 11861689 | 6894089 | 6896195 | 6898302 | 5900407 | 8902512 | 5904617 | | / Cosine. Cotang. | |
| ' Sin | 16 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 391 | 40 | | - | 1 |
| - | 109 | 59 | 58 | 3 57 | 56 | 55 | 154 | 53 | 5 52 | 51 | 8 50 | 7 49 | 148 | 47 | 146 | 45 | 44 | 43 | 42 | 41 | 40 | - | 1 |
| Cosine. | 7919597 | 731155 | 7309568 | 7307583 | 7305597 | .7303610 | .7301625 | .7299635 | 7297646 | 7295657 | .7293668 | 7291677 | 7289686 | 7287695 | 7285703 | 7283710 | 7281716 | 7279792 | 7277728 | 7275732 | 7273736 | Sine. | 1 . |
| Cotang. | 096660 | 0000000 | 071118 | 070494 | 078990 | .06924€ | .068623 | 000890 | -067377 | -066755 | .066134 | .065512 | .064891 | .064271 | -063651 | .063031 | -062411 | ·06, 792 | -061174 | -060556 | 1-059938 -7273736 40 | Tang. | , |
| Tang. | 112000 | 010206 | 693860 | 934147 | 98489 | 935938 | 935783 | 036390 | 936875 | 937421 | 937968 | 938615 | 939062 | 019686 | 940157 | 940706 | 941254 | 941803 | 942352.1 | 942901 | 943451 | Cotang. Tang. | 0 |
| ' Sine. | 1000100 | 1118000 | 6894997 | 6896363 | 6858489 | 6830613 | 8839738 | 6834861 | 6836984 | 6839107 | 6841229 | 1.6843350.938515 1.065512 -7291677 4932-6887765-950070 1.052553 -7249738 28 | 6845471 | 6847591 | 6849711 | 68518301 | 6853948 | 6856066 | 6858184 | 9 6880300 942901 1.060556 7275732 41 | 20 -6862416 -943451 | Cosine. | |
| 1 2 | 10 | 5 | 10 | | | | | | - 00 | | 0 | - | 2 | 0 | 4 | 10 | 9 | 7 | - 00 | 6 | 0 | 1 | 1 |

| 44 Deg. Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. C | | _ | _ | - | _ | - | | _ | - | - | _ | _ | _ | ~ | - | | | _ | ~ | - | | _ | | - | 10 |
|--|------|---------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|---------|-------|
| # Deg. Sinc. Tang. Cotang. Cosine. Yang. Cotang. Cosine. Yang. Cotang. Cosine. Yang. Cotang. Cotang. Cosine. Yang. Cotang. Cotang. Cosine. Yang. Cotang. | | - | 18 | 18 | = 2 | 16 | - | 14 | 133 | 12 | Ξ | 1 | 5 | 00 | - | 9 | 162 | 4 | 000 | 50 | | - | | - | E |
| # Deg. Sine. Tang. Cotang. Cosine. 1 Sine. Tang. Cotang. Cosine. 1 Sine. Tang. Cotang. | | Cosine. | -7110041 | ·7107995 | -7105948 | -7103901 | 7101854 | 9086604 | -7097757 | -7095707 | .7093657 | -7091607 | -7089556 | -7087504 | 12085451 | -7083398 | 7081345 | -7079291 | .7077236 | .7075180 | -7073124 | -7071068 | | Sine. | Des |
| ## Deg. Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. Sine. Tang. Sine. Tang. Cotang. Cosine. Sine. Tang. Sine. Sine. Tang. Sine. Tang. Sine. S | | Cotang. | 1-011115 | 1-010527 | 1-009939 | 1-009352 | 1.008764 | 1.008178 | 1-007591 | 1-007005 | 1-006420 | 1-005834 | 1.005249 | 1-004665 | 1-004080 | 1.003496 | 1-002913 | 1-002329 | 1.001746 | 1-001164 | 1.000581 | 1-000000 | | _ | |
| Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. Sine. Sine | | Tang. | 900686- | -989582 | 891066- | -990734 | -991311 | -991888 | -992465 | -993042 | -993620 | -994199 | 994777 | 995356 | -995935 | -996515 | -997095 | 997675 | 998256 | 998837 | 814666 | 1.00000 | | Cotang. | |
| Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. Sine. Ge946584 965688 1-035530 7-193398 Go2 6990396 977564 1-022950 7-150830 3941 1-6946564 9656813 1-034927 7-191377 5922 6999476 978255 7-148796 3842 2-695076 966813 1-034927 7-19337 5922 6999476 978255 7-148796 3842 2-695076 965813 1-033422 7-183287 5526 6999476 979272 1-021166 7-144762 33644 4-6954949 9667939 1-033122 7-185310 5625 6999476 979272 1-021166 7-144762 3344 4-6954949 9667939 1-033122 7-185310 5625 6-999471 979842 1-020572 7-148796 3344 4-6954949 968631 1-033122 7-185310 5625 6-99988 1-019978 7-142691 3344 7-6961217 9696831 1-031319 7-172238 5226 7-000789 98041 1-019978 7-142691 3344 7-6961217 969631 1-031319 7-172238 5226 7-0007492 981042 1-018979 7-132504 3050 96963305 9-70016 1-030119 7-172135 5226 7-0004942 981254 1-018979 7-132504 3050 96963305 9-70016 1-030119 7-175187 5130 7-009093 982697 1-016423 7-124442 2654 9-6963305 9-700494 9-882125 1-018942 7-124442 2654 9-6963305 9-700494 9-882125 1-018942 7-124442 2654 9-6963305 9-700494 9-882125 1-018942 1-018942 2-1718444 2-167048 9-6963305 9-700494 9-882125 1-018942 1-018942 2-1718444 2-167048 9-6963305 9-700494 9-882125 1-018942 1-018942 2-171844 2-167048 9-9695395 9-70076 1-026049 9-98265 1-01465 7-122303 2-555 1-0697998 9-74724 1-025324 7-167049 9-98556 1-012292 7-114130 2-1598 1-0267998 9-74724 1-025334 7-165999 9-98556 1-012292 7-114130 2-1598 1-0267934 9-9882345 1-012292 7-114130 2-1598 1-024738 7-162424 9-223942 1-01828315 9-76427 1-024738 7-162438 7-102494 9-8828315 9-9882345 1-01828546 7-122393 3-1024238 9-74724 1-025334 7-152394 9-986234 9-9882345 9-9882345 9-9882345 9-9882345 9-988234 | Deg. | Sine. | -7031879 | -7033947 | -7036014 | 7038081 | 7040147 | -7042213 | -7044278 | 7046342 | -7048406 | -7050469 | -7052532 | 7054594 | 7056655 | 7058716 | -7060776 | 7062835 | -7064894 | -7066953 | 1106907 | -7071068 | | Cosine. | 7 |
| ## Deg. Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. Sine. Cosine. Sine. Sine. | 44 | - | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 20 | 51 | 55 | 53 | 541 | 55 | 99 | 57 | 89 | 59 | 09 | | - | 1 |
| Sine. Tang. Cotang. Cosine. Sine. Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. Cosine. Sine. Tang. Cotang. Co | | - | 39 | 38 | 37 | 36 | 35 | 34 | 33 | 32 | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 30 | | - | AR |
| Sine Tang Cotang Cosine Cosine Co | | Cosine. | 7150830 | 7148796 | 7146762 | 7144727 | 7142691 | 7140655 | 7138618 | 7136581 | 7134543 | 7132504 | 7130465 | 7128426 | 7126385 | 7124344 | 7122303 | 7120260 | 7118218 | 7116174 | 7114130 | 7112086 | | Sine. | Dan |
| # Deg. Tang. Cotang. Cosine. Sine. Tang. 16946584 965888 1-035530 7-7193398 6021 6990396 977564 965676 966821 1-034927 7193375 592 699476 977504 965676 966821 1-034927 7193375 592 6994555 9778723 8695267 966873 1-034927 7187333 5724 699683 979272 96954949 967939 1-033722 7187333 5724 699683 979272 96952127 96953 1-033122 7185310 5625 6998711 979842 569951237 969591 1-033192 7175218 525 7700789 980412 96952127 969521 1-031319 7777218 525 7700789 980412 9695239 970761 1-030119 777218 5229 77004942 981554 9695335 970761 1-028921 7777218 5229 77004942 981554 9695335 970761 1-028922 77771134 5229 7700718 982491 11695955 977771 1134 4937 7701324 1-988326 11695955 97777 1-028922 77771134 5229 770071167 983269 11695955 977721 1-028922 77771134 5229 7700718 984987 114695581 97359 1-027724 7715916 16893 977071 116998 9477 7701334 984987 1146975821 97359 1-025334 7715998 9437 77023601 985707 1169798 9772741 9887856 11695988 976477 1-025334 7715998 9437 77023601 987856 11695988 976477 1-025334 7715998 97027741 9887856 11695988 976477 1-025334 7715989 97027741 9887856 11695988 976477 1-025334 7715989 970277741 9887856 11695988 976477 1-025334 7715989 970277741 9887856 11695988 976477 1-025334 7715989 97027774 1-025334 7715989 97027 | | Cotang. | 1-022950 | 1.022355 | 1-021760 | 991120-1 | 1-020572 | 816610-1 | 1-019385 | 1.018792 | 661810-1 | 1.017607 | 1.017015 | 1-016423 | 1.015832 | 1-015241 | 1-014651 | 1-014061 | 1.013471 | 1.012881 | 1-012292 | 1-011703 | | Tang. | ۱ |
| 44 Deg. Sine. Tang. Cotang. Cosine. Sine. 6946584 965688 1-035530 77193398 6021 6990396 1-6948676 966251 1-034927 7719335 5722 6992476 3-6950477 966813 1-034927 7719335 5724 6996633 4-6954949 967939 1-033427 7719325 5724 6996635 5-6950739 968603 1-03322 77187335 5724 6996635 5-6957039 968603 1-03322 77187323 5626 7000789 6-6959128 9690671 1-031919 7717213 2635 77002086 7-6961217 969631 1-031919 7717213 5229 77007018 9-6965392 970761 1-030119 7717213 5229 77007018 9-6965392 970761 1-030119 7717213 5229 77007018 9-6965392 970761 1-030119 7717213 5229 77007018 11-697651 1-028921 77171134 4932 77013241 12-6977995 977891 1-028921 77171134 4932 77013415 13-6977995 974724 1-028921 77160989 4437 77025601 14-697681 97329 1-028534 77160989 4437 77025601 15-6977995 974724 1-025537 77160989 4437 77025601 16-6979988 974724 1-025538 77160989 4437 7702561 18-6982671 1-025334 7716989 4437 77029811 18-6982671 1-025334 77158959 4140 77029811 18-6988291 976895 1-024738 7715885 40 18-6988315 976895 1-024738 7715885 40 | | Tang. | 977564 | 978133 | 978702 | 979272 | 979842 | 980412 | 886086 | 981554 | 982125 | 169286- | 983269 | 983841 | 984414 | 984987 | 985560 | 986133 | 1986707 | 987282 | 98786 | 988431 | | Cotang. | |
| # Deg. Sine. Tang. Cotang. Cosine. / / / / / / / / / / / / / / / / / / / | Deg. | Sine. | 6990396 | 6992476 | 6994555 | 6996693 | 6998711 | 7000789 | 7002866 | 7004942 | 7007018 | 7009093 | 7011167 | 7013241 | 7015314 | 7017387 | 7019459 | 7021531 | 7023601 | 7025672 | 7027741 | 7029811 | | Cosine. | |
| Sine. Tang. Cotang. Cosine. | 44 | | 1 57 | 22 | 23 | 24 | 25 | 26 | 27 | 88 | 68 | 30 | 31 | 35 | 33 | 34 | 35 | 36 | 37 | 38 | 89 | 40 | | - | ı |
| Sine. Tang. Cotang. Cosine. Sine. Tang. Cotang. Cosine. 6948676 -96588 1-035530 7-193398 69548676 -965815 1-034927 7-1913373 6954949 696793 1-033723 7-189355 6954949 696793 1-033122 7-185310 69559128 -969667 1-031919 7-179238 69559128 -969667 1-031919 7-179238 6955392 -970761 1-030119 7-179238 6965392 -970761 1-030119 7-171316 6965592 -970761 1-028927 7-171316 6965592 -970761 1-028927 7-1160989 6965392 -970761 1-028927 7-1160989 6965392 -973590 1-027724 7-160989 69768214 -975259 1-025331 7-160989 69882315 -975859 1-024738 7-158955 6988234 -976427 1-02413 7-158955 69882315 -975859 1-024738 7-160989 69882315 -976427 1-024141 7-158955 69882315 -976427 1-024141 7-158955 69882315 -976427 1-02438 7-158955 69882315 -976427 1-024141 7-158955 69882315 -976427 1-024141 7-158955 69882315 -976427 1-024141 7-158955 69882315 -976427 1-024414 7-158955 69882315 -976427 1-024414 7-158955 69882315 -976427 1-024414 7-158955 69882315 -976427 1-024414 7-158955 69882315 -976427 1-024414 7-158955 69882315 -976427 1-024414 7-158955 69882315 -976427 1-024414 7-158965 7-005406 | | - | 09 | 69 | 58 | 57 | 99 | 55 | 54 | 53 | 52 | 51 | 50 | 49 | 48 | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 40 | ` | ¥ |
| Sine. Tang. Cotang. | | Cosine. | 7193398 | 7191377 | 7189355 | 7187333 | 7185310 | 7183287 | 7181263 | 7179238 | -7177213 | 7175187 | .7173161 | -7171134 | -7169106 | -7167078 | 7165049 | -7163019 | .7160989 | 7158959 | 7156927 | 7154895 | 7152863 | Sine. | Dog 4 |
| Sine. Tang. Sine. Sine. Sine. Sine. Sine. 6946584 965688 9650767 9668181 69546949 967939 69540949 967939 69540949 967939 6956392 970196 9665392 970761 16969565 971891 16957651 973259 16957651 973259 16957651 973259 1695897865 971891 16957905 971891 16957905 971891 16957905 971765 16957905 971765 16957905 971765 1695897865 977895 | | Cotang. | 1-035530 | 1-034927 | 1.034325 | 1-033723 | 1.033122 | 1-032520 | 1-031919 | 1.031319 | 1.030719 | 1.030119 | 1-029520 | 1.028921 | 1.028322 | 1.027724 | 1.027126 | 1.026528 | 1.025931 | 1-025334 | 1.024738 | 1.024141 | 1.023546 | _ | |
| Sine. 6546584 1 -6948676 2 -6952858 4 -6954949 5 -6957039 6 -6957039 7 -696732 10 -696732 11 -6965392 11 -6965392 11 -6965392 11 -6965392 11 -6965392 11 -6965392 11 -6965392 11 -6965392 11 -6965392 11 -6965392 11 -6965392 11 -6965392 11 -6965392 12 -697165 13 -697165 13 -697165 13 -697165 14 -6958315 15 -6988315 | | | -965688 | .966251 | -966813 | 967376 | -967939 | -968503 | 1290696 | 189696 | 961026 | 197076 | -971326 | 168116 | | 973023 | 973590 | 974156 | -974724 | -975291 | 975859 | -976427 | -976995 | Cotang. | - |
| 4 0 1 8 8 4 6 9 7 8 6 0 1 8 8 4 6 9 9 7 8 6 0 0 1 2 8 8 4 6 9 9 1 2 8 6 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 | Deg. | Sine. | 6946584 | 6948676 | 6950767 | 8923898 | 6954949 | 6822039 | 6959128 | 6961217 | 6963305 | 6965392 | 6967479 | 6969565 | 6971651 | 6973736 | 6975821 | 6977905 | 8866169 | 6982071 | 6984153 | 6986234 | 6988315 | Cosine. | |
| | 4 | - | 0 | 1 | C.S | 63 | 4 | 2 | | | | 6 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 181 | 119 | 20 | - | |

ARTICLE XLVI.

Versed Sines.

The Versed Sine of an angle or are, AB, Fig. 58, is that part, WA, of the diameter, DA, which is between the sine, BW, and the extremity, A, of the arc.

Thus,

WA (=DT) is the versed sine of AB and of BCDEFA.

WD(=TA) is the versed sine of BCD and of ABCDE.

The versed sine is=radius minus cosine. (See p. 121.) But in the second quadrant C D (counting from A), or in angles of between 90° and 180°, and in the third quadrant D F, or between 180° and 270°, the cosines TX etc., extend from the center to the left, and are regarded as negative or minus. Hence in angles of more than 90° and less than 270°, the numerical value of the versed sine is radius plus cosine.

On pages 170 to 192 is a Table of Natural Versed Sines (those of circles whose radius is 1) for all angles from 0° to 360°.

The versed sines of angles increase from 0 at 0° to 2 at 180°; and then decrease from 2 at 180° to 0 at 360°. The angles are read downward on the left of the column, from 0° to 180°; and upward on the right, from 180° to 360°. Each versed sine thus corresponds to two angles, and when an angle is to be found from the table by means of its versed sine, we must decide from the circumstances of the case which of the two is the angle required. See Remark, p. 123.

To find the versed sine of an angle containing an odd number of minutes, take the mean between those immediately above and below it in the table. Thus, to find the versed sine of 89° 57′ (the versed sines vary most rapidly at 90° and at 270°), we find in the table the versed sine of 89° 56′ (9988) and that of 89° 58′ (9994); and the mean between these two, or '9991, is the required versed

sine of 89° 57'.

| 01 | | 0, | 01 | 123 | 0, | 01 | | 0, | 01 | | 101 |
|----------|--------|-------|----------|-------|-------|----------|----------------|-------|----------|-------|--|
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|----------|----------------------|-------|----------|-------------------------|-------|----------|----------------|-------|----------------|----------------|---------|
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| 46 | 1591 | 14 | 46 | 1785 | 14 | 46 | 1993 | 12 | 46 | *2203 *2207 | 1 |
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| 26 | 1655 | 34 | 26 | 1852 | 34 | 26 | 2059 | 34 | 26 | ·2276 ·2280 | 20 |
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| 30 | 1661 | 30 | 30 | 1859 | 30 | 30 | *2066 | 30 | 80 | 2284 | 8 |
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| | ****** | | 56 | 1903 | 4 | 56 | 2113 | 4 | 56 | 2332 | |
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| 400 2466 810 1214 166188 200 | *2340 *2343 *2347 *2351 *2355 *2358 *2362 *2360 *2370 *2373 *2377 | 60 58 56 54 52 50 47 46 44 42 40 | 0 / 42 0 2 4 6 8 10 12 14 16 18 20 22 | *2569 *2572 *2576 *2580 *2584 *2588 *2592 *2596 *2600 *2604 *2608 | 60 58 56 54 52 50 48 46 44 42 40 | 44 0 2 4 6 8 10 12 14 16 18 20 | 2807 2811 2815 2819 2823 2827 2831 2835 2839 2843 2847 | 60 58 56 54 52 50 48 46 44 42 40 | 6 8 10 12 14 16 18 20 | *3058 *3058 *3062 *3066 *3070 *3074 *3079 *3083 *3087 *3091 *3095 | 60 58 56 54 52 50 48 46 44 42 40 |
|---|--|---|--|---|---|---|---|---|---|--|---|
| 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 | 2381 2385 2388 2392 2490 2404 2407 2411 2415 2419 2422 2126 2430 2434 2438 2441 2444 2448 | 38 36 31 32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 | 224 246 228 330 324 346 340 424 446 448 50 524 556 558 | *2612 *2615 *2619 *2627 *2631 *2635 *2636 *2647 *2651 *2655 *2659 *2663 *2667 *2671 *2671 *2675 *2679 *2682 | 38 36 34 30 28 26 24 22 20 18 16 14 12 10 8 6 | 222 244 268 288 30 322 344 368 388 442 444 448 50 522 546 558 | 2851 2855 2859 2863 22867 22876 22876 22876 22884 22892 22904 29004 2904 2912 2917 2917 2925 | 38 36 31 32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 | 22 24 26 28 30 32 34 36 38 40 42 44 46 50 52 54 55 58 | 3100 3104 3108 3112 3125 3126 3125 3123 3138 3142 3146 3155 3159 3163 3167 3176 | 38 36 34 32 30 28 26 24 22 20 18 16 14 14 14 12 10 8 6 4 4 |
| 60 2 4 4 1 0 2 4 6 6 8 8 10 12 14 4 16 18 20 22 24 24 25 30 32 34 44 44 46 48 48 50 52 54 56 66 68 60 | 2453 2453 2457 2461 2464 2468 2472 2476 2476 2480 2484 2187 2499 2503 2510 2518 2522 2526 2530 2534 2545 2537 2541 2545 2555 2568 2568 2568 | 319 0 60 58 56 54 52 52 48 46 44 42 42 42 43 38 36 34 32 32 32 34 32 32 34 32 32 34 32 34 32 34 32 34 34 34 32 34 34 34 34 34 34 34 34 34 34 | 60 0 43 0 2 2 4 4 6 8 10 112 114 116 116 118 20 22 22 23 33 34 40 42 44 46 48 80 52 54 56 60 60 60 60 60 60 60 60 60 60 60 60 60 | *2686 *2686 *2690 *2694 *2702 *2704 *2718 *2726 *2734 *2738 *2746 *2754 *2755 *2766 *2770 *2754 *2754 *2754 *2754 *2754 *2754 *2754 *2754 *2754 *2755 | 317 0 60 58 54 52 50 48 44 42 42 43 38 36 34 32 38 36 48 41 42 42 42 43 44 44 42 42 43 44 44 44 45 46 47 48 48 48 48 48 48 48 48 48 48 | 60 2 2 4 6 8 8 10 112 114 16 118 20 222 22 24 42 26 38 38 38 40 42 24 44 46 48 80 50 50 50 50 50 50 50 50 50 50 50 50 50 5 | -2929 -2929 -2933 -2937 -2941 -2945 -2956 -2956 -2970 -2974 -2958 -2983 -2987 -2991 -2995 -3016 -3016 -3024 | 315 0 60 58 56 54 52 50 48 44 42 40 40 38 36 36 31 32 28 26 20 20 18 16 16 16 17 18 18 18 18 18 18 18 18 18 18 | 60 47 0 2 2 4 6 8 8 10 112 114 116 118 118 120 222 244 446 488 548 548 548 558 568 60 | 3180 -3180 -3180 -3189 -3193 -3193 -3193 -3201 -3214 -3221 -3221 -3224 -3223 -3224 -3223 -3226 -3224 -3223 -3226 - | 313 0 60 58 56 56 54 52 56 58 59 60 48 48 48 48 48 48 48 48 48 48 |

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| 14 16 18 | 1511 | 16 | |
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| 7 21 | 1554 1557 | :365 | 1 |
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| 28 | 1.30.5 | 32 | |
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| 36 | 1575 ; 1579 1582 | 24 | |
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| 50 | 1597 | 10 | |
| 52 | 1601 | ۶. | |
| 54 56 | ·1604 ·1607 | 6 4 | |
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| 33 0 | 1613 | o / (ii) | :: |
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| 33 0 2 | 1613 1616 1620 1623 | \ &&&&& | :: |
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| 33 0 2 1 6 8 | 1613 1616 1620 1623 1626 1629 1632 | 、60.8.6.6.7.8.6.4.8 0 | :: |
| 33 0 2 1 6 8 10 12 14 | 1613 1616 1620 1623 1626 1629 1632 1636 | 66.65.53.54.6 | :: |
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| 33 0 2 1 6 8 10 12 14 16 18 12 22 24 6 25 12 14 16 15 18 18 18 18 18 18 18 18 18 18 18 18 18 | 1613 1616 1629 1623 1629 1632 1636 1632 1642 1645 1648 1652 1658 | \$65.53.54\$\$\$\$6.53.8 | :: |
| 33 0 2 4 6 8 8 100 124 166 188 1 202 244 265 275 275 275 275 275 275 275 27 | 1613 1616 1623 1626 1629 1632 1632 1642 1642 1648 1652 1655 1638 | | :: |
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| 33 0 2 1 1 6 8 10 2 1 1 4 1 6 8 10 2 2 1 4 6 6 6 10 2 2 1 4 6 6 6 10 2 2 1 4 6 6 6 10 2 2 1 4 6 6 6 10 2 1 6 6 10 2 1 6 6 10 2 1 6 6 10 2 1 6 10 2 | 1613 1616 1626 1623 1626 1636 1636 1636 | | ;; |
| 33 0 2 4 6 8 10 12 14 14 14 18 20 22 14 26 50 02 15 55 | 1613 1616 1626 1623 1626 1636 1636 1636 | 로션등급성공수목품임육수용표성공수위원위 6 | |
| 33 0 2 1 6 8 10 2 14 6 8 10 2 14 16 8 10 2 2 14 6 8 10 2 2 14 16 18 10 2 2 14 6 15 10 10 10 10 10 10 10 10 10 10 10 10 10 | 1613 1616 1629 1623 1629 1632 1632 1639 1645 1648 1655 1668 1664 1664 1664 1674 1674 1674 | \$4828344\$\$\$\$\$\$\$\$\$\$\$\$\$\$ | , |
| 33 9 2 4 6 8 10 2 14 16 8 20 2 24 26 5 30 2 1 1 36 8 40 42 1 | 1613 1616 1629 1623 1629 1632 1632 1632 1645 1648 1655 1648 1655 1658 1664 1674 1677 1677 1689 1674 | \$65538644444655386555444 | iii |
| 33 0 2 4 6 8 10 2 14 6 8 10 2 2 2 2 4 6 10 2 2 2 4 6 10 10 10 10 10 10 10 10 10 10 10 10 10 | 1613 1616 1629 1623 1629 1636 1636 1636 1642 1645 1655 1655 1655 1661 1661 1671 1677 1677 | 電台活法記述◆各無益者等。 | n |
| 33 0 2 4 6 8 10 2 14 16 8 10 2 2 14 16 8 10 2 2 14 16 8 10 2 2 14 16 16 16 16 16 16 16 16 16 16 16 16 16 | 1613 1616 1629 1626 1629 1636 1639 1642 1645 1645 1652 1658 1661 1661 1671 1668 1671 1674 1684 1684 1684 1685 1674 1688 | \$68232444446833445411\$6823244444 | n |
| 33 0 2 4 6 8 0 10 2 14 6 8 0 10 2 14 6 8 0 2 2 2 2 5 0 0 2 15 6 0 5 4 0 2 2 14 6 4 5 0 10 2 10 10 10 10 10 10 10 10 10 10 10 10 10 | 1613 1616 1629 1623 1629 1636 1632 1642 1645 1645 1655 1655 1661 1661 1661 1671 1677 1680 1681 1681 1681 1681 1681 1681 1681 | 電台活法記述◆各無益者等。 | |
| 33 0 2 4 6 8 0 10 2 14 6 8 0 10 2 14 6 8 0 2 2 2 2 5 0 0 2 15 6 0 5 4 0 2 2 14 6 4 5 0 10 2 10 10 10 10 10 10 10 10 10 10 10 10 10 | 1613 1616 1629 1626 1629 1636 1636 1636 1642 1642 1645 1652 1658 1664 1658 1664 1674 1677 1684 1684 1684 1684 1684 1684 1684 1684 | > 8.6853384944946833866334444444 | |
| 33 0 2 4 6 8 0 10 2 14 6 8 0 10 2 14 6 8 0 2 2 2 2 5 0 0 2 15 6 0 5 4 0 2 2 14 6 4 5 0 10 2 10 10 10 10 10 10 10 10 10 10 10 10 10 | 1613 1616 1629 1626 1629 1636 1636 1636 1642 1642 1645 1652 1658 1664 1658 1664 1674 1677 1684 1684 1684 1684 1684 1684 1684 1684 | 、多位是在22条条等要要各类的形式表达的时间与12至12至12。 。 | |
| 33 0 2 4 6 8 10 2 14 16 8 10 2 2 14 16 8 10 2 2 14 16 8 10 2 2 14 16 16 16 16 16 16 16 16 16 16 16 16 16 | 1613 1616 1623 1626 1629 1632 1632 1632 1645 1645 1645 1655 1658 1664 1664 1671 1677 1680 1671 1677 1680 1690 1690 1690 1690 1690 1690 1690 169 | > 8.6853384944946833866334444444 | |

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|----------------|----------------|----------|----------|----------------|----------|----------|----------------|----------|----------|----------------|-----|
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| 56 58 60 7 2 4 4 6 8 10 112 114 116 118 20 22 24 26 28 32 34 | 1·1207 1·1219 1·1229 1·1224 1·1236 1·1242 1·1248 1·1259 1·1256 1·1271 1·1276 1·1288 1·1294 1·1299 1·1305 1·1311 1·1311 | 2 63 0 0 60 556 554 42 42 42 83 86 83 82 83 82 83 83 83 83 83 83 83 83 83 83 83 83 83 | 60 99 0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 | 1.1559 1.1564 1.1576 1.1576 1.1582 1.1587 1.1598 1.1695 1.1605 1.1616 1.1622 1.1633 1.1639 1.1645 1.1645 | 2 61 0 0 58 564 552 550 446 442 440 838 36 32 82 82 82 82 82 82 82 82 82 82 82 82 82 | 58 60 , 101 0 2 2 4 6 6 8 10 12 14 16 18 20 22 24 26 28 80 | 1-1902 1-1908 1-1914 1-1920 1-1925 1-1931 1-1937 1-1948 1-1954 1-1954 1-1954 1-1965 1-1971 1-1971 1-1971 1-1971 1-1982 1-1988 1-1994 1-1994 | 2 0 0 688 556 552 550 488 444 422 400 888 886 884 882 880 880 | 60 0 , 103 0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 88 | 1-2244 1-2250 1-2255 1-2261 1-2267 1-2272 1-2284 1-2284 1-2289 1-2300 1-2312 1-2317 1-2317 1-2329 1-2334 1-2346 1-2346 | 0 |
| 56 58 60 7 2 4 6 8 10 12 14 16 18 20 22 24 26 26 33 34 36 36 36 36 36 36 36 36 36 36 36 36 36 | 1·1207 1·1219 1·1219 1·1224 1·1236 1·1236 1·1242 1·1253 1·1259 1·1271 1·1276 1·1282 1·1299 1·1305 1·1305 1·1311 1·1317 1·1317 1·1317 | 2 63 0 0 58 554 46 442 49 88 86 84 82 82 82 82 82 82 82 82 82 82 82 82 82 | 60 99 0 2 4 6 8 10 112 14 16 18 20 22 24 26 28 30 32 36 36 | 1-1559 1-1564 1-1570 1-1576 1-1587 1-1587 1-1589 1-1605 1-1610 1-1622 1-1628 1-1639 1-1639 1-1645 1-1656 | 2 61 0 0 58 564 552 550 446 442 440 838 36 32 82 82 82 82 82 82 82 82 82 82 82 82 82 | 58 60 , 101 0 2 4 6 8 8 10 12 14 14 16 18 20 22 24 24 26 28 80 80 80 | 1-1902 1-1908 1-1914 1-1920 1-1937 1-1937 1-1942 1-1954 1-1955 1-1971 1-1977 1-1982 1-1988 1-1994 1-1994 1-1999 1-1999 | 2 0 0 60 68 564 52 50 88 86 84 44 42 88 88 82 28 26 48 82 26 82 82 82 82 82 82 82 82 82 82 82 82 82 | 60 0 0 0 2 2 4 6 6 8 8 10 112 114 114 118 220 224 226 28 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 | 1-2244 1-2250 1-2255 1-2261 1-2272 1-2272 1-2278 1-2289 1-2295 1-2306 1-2312 1-2312 1-2312 1-2323 1-2323 1-2323 1-2324 1-2344 | 0 |
| 56 58 60 7 2 4 6 8 10 12 14 16 18 20 22 24 26 28 33 34 38 38 38 38 38 38 38 38 38 38 38 38 38 | 1-1207 1-1219 1-1219 1-1224 1-1230 1-1236 1-1248 1-1253 1-1253 1-1256 1-1271 1-1265 1-1271 1-1282 1-1288 1-1299 1-1305 1-1317 1-1317 1-1317 1-1317 1-1317 | 2 63 0 0 586 554 552 488 464 442 438 864 832 832 832 832 832 832 832 832 832 832 | 60 99 0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 | 1:1559 1:1564 1:1570 1:1576 1:1587 1:1587 1:1587 1:1593 1:1699 1:1610 1:1616 1:1628 1:1633 1:1639 1:1645 1:1650 1:1650 1:16562 | 2 61 0 0 58 564 552 550 446 442 440 838 36 32 82 82 82 82 82 82 82 82 82 82 82 82 82 | 58 60 0 , 101 0 2 4 6 8 10 12 114 14 16 18 20 22 24 22 24 22 28 80 32 32 32 32 | 1-1902 1-1908 1-1914 1-1925 1-1937 1-1937 1-1948 1-1954 1-1959 1-1965 1-1977 1-1982 1-1988 1-1999 1-1905 1-2005 | 2 0 0 60 68 564 52 50 88 86 84 44 42 88 88 82 28 26 48 82 26 82 82 82 82 82 82 82 82 82 82 82 82 82 | 60 0 0 0 2 2 4 6 6 8 8 10 112 114 114 118 220 224 226 28 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 | 1-2244 1-2250 1-2255 1-2261 1-2267 1-2272 1-2284 1-2284 1-2289 1-2300 1-2312 1-2317 1-2317 1-2329 1-2334 1-2346 1-2346 | 0 |
| 56 58 60 7 2 4 6 8 10 114 116 118 20 22 24 26 28 30 32 33 34 36 36 36 36 36 36 36 36 36 36 36 36 36 | 1-1207 1-1219 1-1219 1-1224 1-1230 1-1236 1-1248 1-1259 1-1265 1-1256 1-1276 1-1282 1-1294 1-1294 1-1294 1-1305 1-1311 1-1311 1-1311 1-1312 1-1328 1-1328 | 2 63 0 0 60 556 552 550 486 444 429 888 884 822 828 828 828 828 828 828 828 | 60 99 0 2 4 6 8 10 112 144 116 118 20 22 24 26 28 30 32 34 36 36 38 34 36 36 34 40 | 1.1559 1.1564 1.1570 1.1570 1.1582 1.1582 1.1599 1.1605 1.1616 1.1622 1.1638 1.1639 1.1639 1.1650 1.1650 1.1650 1.1650 1.1650 1.1650 1.1650 1.1650 1.1650 1.1650 1.1650 1.1650 1.1650 1.1650 1.1650 | 2 61 0 0 60 586 554 550 448 444 420 388 364 362 262 262 262 262 262 262 262 262 262 | 58 60 0 , 101 0 2 4 6 6 8 100 114 16 18 20 222 24 26 283 323 334 | 1-1902 1-1908 1-1914 1-1920 1-1937 1-1937 1-1942 1-1954 1-1955 1-1971 1-1977 1-1982 1-1988 1-1994 1-1994 1-1999 1-1999 | 2 0 0 60 68 564 52 50 88 86 84 44 42 88 88 82 28 26 48 82 26 82 82 82 82 82 82 82 82 82 82 82 82 82 | 60 0 2 2 4 6 6 8 100 112 114 116 118 220 224 224 226 330 332 332 | 1-2244 1-2250 1-2255 1-2267 1-2267 1-2272 1-2284 1-2289 1-2306 1-2302 1-2317 1-2323 1-2329 1-2340 1-2340 1-2351 1-2351 1-2351 | 0 |
| 56 58 60 7 2 4 6 8 10 12 14 16 18 18 20 22 24 26 28 33 34 36 36 36 36 36 36 36 36 36 36 36 36 36 | 1-1207 1-1219 1-1219 1-1224 1-1230 1-1242 1-1248 1-1259 1-1255 1-1271 1-1276 1-1288 1-1299 1-1305 1-1311 1-1317 1-1317 1-1334 1-1334 1-1334 1-1334 | 2 63 0 0 586 554 552 488 464 442 438 864 832 832 832 832 832 832 832 832 832 832 | 60 99 0 2 4 6 8 10 114 116 118 202 244 268 203 303 323 346 388 | 1.1559 1.1564 1.1570 1.1570 1.1582 1.1582 1.1599 1.1605 1.1616 1.1622 1.1638 1.1639 1.1639 1.1650 1.1650 1.1650 1.1650 1.1650 1.1650 1.1650 1.1650 1.1650 1.1650 1.1650 1.1650 1.1650 1.1650 1.1650 | 2 61 0 0 60 586 554 550 448 444 420 388 364 362 262 262 262 262 262 262 262 262 262 | 58 60 0 , 101 0 2 2 4 6 8 8 100 12 14 14 18 200 222 24 26 28 80 80 82 83 84 84 84 | 1-1902 1-1908 1-1914 1-1920 1-1925 1-1931 1-1932 1-1942 1-1948 1-1959 1-1965 1-1971 1-1977 1-1982 1-1988 1-1999 1-2005 1-2011 1-2012 | 2 5 9 0 0 60 588 554 466 442 400 888 886 884 828 820 828 822 822 822 823 823 824 823 824 823 824 823 824 824 824 825 824 825 824 825 824 825 824 825 824 825 824 825 824 825 824 825 824 825 824 825 824 825 825 824 825 825 825 825 825 825 825 825 825 825 | 60 0 0 0 2 4 6 6 8 10 114 16 18 20 22 24 26 28 30 82 24 26 28 30 82 24 26 28 30 82 24 26 28 30 82 24 26 26 26 26 26 26 26 26 26 26 26 26 26 | 1-2244 1-2250 1-2250 1-2261 1-2261 1-2267 1-2272 1-2284 1-2289 1-2300 1-2312 1-2317 1-2329 1-2334 1-2346 1-2357 1-2357 1-2368 | 0 |
| 56 58 60 7 2 4 6 8 10 114 116 118 202 224 226 228 303 324 404 414 414 | 1·1207 1·1219 1·1219 1·1224 1·1230 1·1242 1·1248 1·1259 1·1265 1·1276 1·1288 1·1294 1·1294 1·1299 1·1305 1·1311 1·1311 1·1323 1·1324 1·1334 1·1340 1·1340 | 2 63 0 0 658 556 552 558 486 444 440 886 844 822 822 826 824 826 824 826 824 826 824 826 824 826 824 826 824 826 824 826 824 826 824 826 826 824 826 826 824 826 826 826 826 826 826 826 826 826 826 | 60 99 0 2 4 6 8 10 112 144 116 118 20 22 24 26 28 30 32 34 36 36 38 34 36 36 34 40 | 1.1559 1.1564 1.1570 1.1576 1.1582 1.1587 1.1599 1.1605 1.1616 1.1622 1.1633 1.1639 1.1650 1.1650 1.1650 1.1650 1.1650 1.1650 1.1650 | 2 61 0 0 60 88 554 550 488 444 420 432 838 834 832 832 832 834 832 832 833 834 832 833 834 832 833 834 832 833 834 832 833 834 832 833 834 832 834 832 834 832 834 832 834 832 834 834 832 834 834 834 834 834 834 834 834 834 834 | 58 60 0 2 4 6 8 10 114 16 18 20 22 24 28 30 32 32 34 38 38 | 1-1908 1-1908 1-1914 1-1920 1-1925 1-1937 1-1942 1-1954 1-1959 1-1965 1-1971 1-1977 1-1988 1-1999 1-2005 1-2011 1-2016 1-2022 1-2022 | 2 | 60 0 0 2 2 4 6 8 10 12 14 16 18 22 24 24 24 24 28 30 32 34 36 38 38 38 38 38 38 | 1-2244 1-2250 1-2250 1-2251 1-2261 1-2267 1-2278 1-2284 1-2289 1-2396 1-2312 1-2312 1-2312 1-2312 1-2312 1-2312 1-2312 1-2312 1-2312 1-2312 1-2351 1- | 0 |
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| 05 0 2 2 4 6 8 8 10 12 14 16 18 20 22 24 24 26 28 30 32 32 34 44 46 48 46 48 50 | 1:2588 1:2594 1:2694 1:2611 1:2611 1:2612 1:2628 1:2633 1:2639 1:2650 1:2667 1:2672 1:2684 1:2684 1:2684 1:2712 1:2712 1:2712 1:2712 1:2712 1:2712 1:2712 1:2712 1:2712 1:2712 1:2712 1:2712 1:2712 1:2712 | 6 / 60 658 556 552 550 550 552 48 464 442 440 28 366 364 322 224 224 220 18 16 14 11 10 | 0 / 107 0 2 4 6 6 8 10 114 116 114 116 114 115 115 115 115 115 115 115 115 115 | 1·2924 1·2929 1·2940 1·2946 1·2952 1·2968 1·2968 1·2974 1·2979 1·2996 1·2996 1·3007 1·3013 1·3018 1·3018 1·3018 1·3040 1·3057 1·3057 1·3057 | 60 658 556 552 550 552 552 552 552 552 552 552 552 | 0 / 109 0 2 4 6 8 10 112 114 116 118 20 222 224 226 228 30 32 32 34 34 6 42 42 42 42 45 50 6 50 | 1-8256 1-8261 1-8267 1-8272 1-8278 1-8289 1-3294 1-8300 1-3316 1-3316 1-3327 1-3323 1-3334 1-3344 1-3349 1-3355 1-3351 1-3365 1-3371 1-3382 1-3382 1-3383 1-3385 1- | 60 58 556 554 552 550 488 486 444 442 440 388 322 26 24 222 188 166 114 112 | 0 / 111 0 0 2 4 6 6 8 8 10 114 16 114 16 114 120 222 224 226 228 30 322 324 324 424 446 48 48 50 | 1.3584 1.3589 1.3690 1.3601 1.3611 1.3612 1.3622 1.3632 1.3643 1.3643 1.3660 1.3665 1.3676 1.3676 1.3682 1.3692 1.3692 1.3693 1.3692 1.3693 1.3703 1. | |
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| 4 | 1.3757 | 56 | 4 | 1.4078 | 56 | 4 | 1.4394 | 56 | 4 | 1.4705 | 5 |
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| 12 | 1.3778 | 48 | 12 | 1.4099 | 48 | 12 | 1.4415 | 48 | 12 | 1:4726 | 4 |
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| 20 22 | 1:3800 | 40 38 | 20 | 1.4126 | 38 | 20 22 | 1.4441 | 40 38 | 20 | 1:4746 | 3 |
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| 34 | 1.3838 | 26 | 34 | 1.4158 | 26 | 34 | 1:4472 | 26 | 34 | 1.4782 | 2 |
| 36 | 1.3843 | 24 | 36 | 1.4163 | 24 | 36 | 1.4478 | 24 | 36 | 1.4787 | 2 |
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| 40 | 1.3854 | 20 | 40 | 1.4173 | 20 | 40 | 1:4488 | 20 | 40 | 1.4797 | 2 |
| 42 | 1:3859 | 18 | 42 | 1.4179 | 18 | 42 | 1.4493 | 18 | 42 | 1.4802 | 1 |
| 44 | 1.3864 | 16 | 44 | 1.4184 | 16 | 44 | 1:4498 | 16 | 44 | 1.4807 | 1 |
| 46 | 1.3870 | 14 | 46 | 1.4189 | 14 | 46 | 1:4504 | 14 | 46 | 1.4812 | 1 |
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| 52 | 1.3886 | 8 | 52 | 1.4205 | 8 | 52 | 1.4519 | 8 | 52 | 1'4828 | 0 0 |
| 54 | 1:3891 | 6 | 54 | 1.4210 | 6 | 54 | 1.4524 | 6 | 54 | 1.4833 | |
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| 58 | 1.3902 | 2 | 58 | 1.4221 | 2 | 58 | 1.4535 | 2 | 58 | 1.4843 | 4.0 |
| 60 | 1.3907 | 247 0 | 60 | 1.4226 | 245 0 | 60 | 1.4540 | 243 0 | 60 | 1.4848 | 241 |
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| 6 | 1.3923 | 54 | 6 | 1.4242 | 54 | 6 | 1:4555 | 54 | 6 | 1.4863 | 5 |
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| 14 | 1.3945 | 46 | 14 | 1.4263 | 46 | 14 | 1'4576 | 46 | 14 | 1.4884 | 4 |
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| 18 | 1.3955 | 42 | 18 | 1.4274 | 42 | 18 | 1:4586 | 42 | 18 | 1.4894 | 4 |
| 20 | 1.3961 | 40 | 20 | 1.4279 | 40 | 20 | 1.4592 | 40 | 20 | 1.4899 | 4 |
| 22 | 1.3966 | 38 | 22 | 1.4284 | 38 | 22 | 1.4597 | 38 | 22 | 1.4904 | 3 |
| 24 | 1.3971 | 36 | 24 | 1'4289 | 36 | 24 | 1.4602 | 36 | 24 | 1.4909 | 3 |
| 26 | 1.3977 | 34 | 26 | 1.4295 | 34 | 26 | 1.4607 | 34 | 26 | 1.4914 | 3 |
| 28 | 1.3982 | 32 | 28 | 1.4300 | 32 | 28 | 1:4612 | 32 | 28 | 1.4919 | 3 |
| 30 | 1.3987 | 30 | 30 | 1:4305 | 30 | 30 | 1.4617 | 30 | 30 | 1.4924 | 3 |
| 32 | 1.3993 | 28 | 32 | 1.4310 | 28 | 32 | 1:4623 | 28 | 32 | 1.4929 | 2 |
| 34 | 1.3998 | 26 | 34 | 1.4316 | 26 | 34 | 1:4628 | 26 | 34 | 1.4934 | 2 |
| 36 38 | 1.4003 | 24 | 36 | 1.4321 | 24 | 36 | 1:4633 | 24 | 36 | 1.4939 | 2 |
| | 1:4009 | 22 | 38 | 1:4326 | 22 | 38 | 1:4638 | 22 | 38 | 1:4944 | 2 |
| | 1.4014 | 20 18 | 40 42 | 1:4331 1:4337 | 20 18 | 40 42 | 1:4643 | 20 18 | 40 | 1.4950 | 2 |
| 40 | | 16 | 42 | 1.4342 | 16 | 42 | 1:4654 | | 42 | | 1 |
| 40 42 | | | | | | | | 16 | 44 | 1:4960 | 1 |
| 40 42 44 | 1:4025 | | 46 | 1:4347 | 14 | 46 | 1:4659 | 14 | 46 | 1:4965 | 1 |
| 40 42 44 46 | 1.4030 | 14 | 40 | | | 48 | 1:4664 | 10 | 48 | 1.4970 | 1 |
| 40 42 44 46 48 | 1·4030 1·4035 | 12 | 48 | 1:4352 | | | | | | | |
| 40 42 44 46 48 50 | 1.4030 1.4035 1.4041 | 12 10 | 50 | 1.4358 | 10 | 50 | | | 50 | 1:4975 | |
| 40 42 44 46 48 50 52 | 1·4030 1·4035 1·4041 1·4045 | 12 10 8 | 50 52 | 1.4358 1.4363 | 10 8 | 52 | 1:4674 | 8 | 52 | 1.4980 | 1 6 |
| 40 42 44 46 48 50 52 54 | 1:4030 1:4035 1:4041 1:4046 1:4051 | 12 10 8 6 | 50 52 54 | 1.4358 1.4363 1.4368 | 10 8 6 | 52 54 | 1:4674 1:4679 | 8 | 52 54 | 1.4980 1.4985 | 1 |
| 40 42 44 46 48 50 52 | 1·4030 1·4035 1·4041 1·4045 | 12 10 8 | 50 52 | 1.4358 1.4363 | 10 8 | 52 | 1:4674 | 8 | 52 | 1.4980 | 1 11 |

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| 2 | 1.5005 | 58 | 2 | 1.5304 | 58 | - 2 | 1.5597 | 58 | 2 | 1.5883 | 58 |
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| 6 8 | 1.5015 | 54 52 | 6 8 | 1.5314 | 54 52 | 6 8 | 1.5606 | 54 52 | 6 8 | 1:5892 1:5897 | 54 |
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| 12 | 1.2030 | 48 | 12 | 1.5329 | 48 | 12 | 1.5621 | 48 | 12 | 1:5906 | 48 |
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| 18 | 1.5045 | 42 | 16 18 | 1.5344 | 42 | 18 | 1.5635 | 42 | 16 18 | 1.5915 1.5920 | 4 |
| 20 | 1.5050 | 40 | 20 | 1.5348 | 40 | 20 | 1.5640 | 40 | 20 | 1:5925 | 4 |
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| 24 26 | 1.5060 1.5065 | 36 34 | 24 26 | 1.5358 1.5363 | 36 34 | 24 26 | 1.5650 1.5654 | 36 34 | 24 26 | 1.5934 1.5939 | 3 |
| 28 | 1.5070 | 32 | 28 | 1.5368 | 32 | 28 | 1.5659 | 32 | 28 | 1.5944 | 3 |
| 30 | 1.5075 | 30 | 30 | 1.5373 | 30 | 30 | 1.5664 | 30 | 30 | 1.5948 | 3 |
| 32 | 1.5080 | 28 | 32 | 1.5378 | 28 | 32 | 1:5669 | 28 | 32 | 1.5953 | 2 |
| 34 | 1.5085 | 26 24 | 34 36 | 1.5383 1.5388 | 26 24 | 34 36 | 1.5674 1.5678 | 26 24 | 34 36 | 1.5958 1.5962 | 2 2 |
| 38 | 1.5095 | 22 | 38 | 1.2393 | 22 | 38 | 1.5683 | 22 | 38 | 1.5967 | 2 |
| 40 | 1.5100 | 20 | 40 | 1.5398 | 20 | 40 | 1.5688 | 20 | 40 | 1.5972 | 2 |
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| 44 | 1.5110 | 16 14 | 44 | 1.5407 1.5412 | 16 14 | 44 46 | 1.5698 1.5702 | 16 14 | 44 46 | 1.5981 1.5986 | 1 |
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| 50 | 1.5125 | 10 | 50 | 1.5422 | 10 | 50 | 1.5712 | 10 | 50 | 1.5995 | 1 |
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| 54 56 | 1.5135 1.5140 | 6 | 54 56 | 1.5432 | 6 4 | 54 56 | 1.5721 1.5726 | 6 4 | 54 56 | 1.6004 | 1 |
| 58 | 1.5145 | 2 | 58 | 1.5442 | 2 | 58 | 1.5731 | 2 | 58 | 1.6014 | 1 |
| 60 | 1.5150 | 239 0 | 60 | 1.5446 | 237 0 | 60 | 1.5736 | 235 0 | 60 | 1.6018 | 233 |
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| 21 0 | 1.5150 | 60 | 123 0 | 1.5446 | 60 | 125 0 | 1.5736 | 60 | 127 0 | 1.6018 | 6 |
| 2 4 | 1.2122 1.2122 | 58 56 | 2 4 | 1.5451 | 58 56 | 2 4 | 1.5741 1.5745 | 58 56 | 2 4 | 1.6023 | 5 |
| 6 | 1.5165 | 54 | 6 | 1.5461 | 54 | 6 | 1.5750 | 54 | 6 | 1.6032 | 5 |
| 8 | 1.5170 | 52 | 8 | 1.5466 | 52 | 8 | 1.5755 | 52 | 8 | 1.6037 | 5 |
| 10 | 1.5175 | 50 | 10 | 1.5471 | 50 48 | 10 | 1.5760 | 50 | 10 | 1.6041 | 5 |
| 12 14 | 1.5180 1.5185 | 48 46 | 12 14 | 1.5480 | 46 | 12 14 | 1:5764 | 48 46 | 12 14 | 1.6046 | 4 |
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| 24 | 1.5210 | 36 | 24 | 1.5505 | 36 | 24 | 1.5793 | 36 | 24 | 1 6069 1 6074 | 200 |
| 26 | 1.5215 | 34 | 26 | 1.5510 | 34 | 26 | 1.5798 | 34 | 26 | 1.6078 | 8 |
| 28 | 1.5220 | 32 | 28 | 1.2212 | 32 | 28 | 1.5802 | 32 | 28 | 1.6083 | 3 |
| 30 | 1.5225 1.5230 | 30 28 | 30 32 | 1.5519 1.5524 | 30 28 | 30 32 | 1.5807 1.5812 | 30 | 30 32 | 1.6088 1.6092 | 3 2 |
| 34 | 1.5235 | 26 | 34 | 1.5529 | 26 | 34 | 1.5816 | - 26 | 34 | 1.6092 | 2 |
| 36 | 1.5240 | 24 | 36 | 1.5534 | 24 | 36 | 1.5821 | 24 | 36 | 1.6101 | 2 |
| 38 | 1.5245 | 22 | 38 | 1.5539 | 22 | 38 | 1.5826 | 22 | 38 | 1.6106 | 2 |
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| 22 | 1.6207 | 38 | 22 | 1.6477 | 38 | 22 | 1.6739 | 38 | 22 | 1.6992 | 1 |
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| 44 | 1.6257 | 16 | 44 | 1.6525 | 16 | 44 | 1.6786 | 16 | 44 | 1.7038 | |
| 46 | 1.6262 | 14 | 46 | 1.6530 | 14 | 46 | 1.6790 | 14 | 46 | 1.7042 | 1 |
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| 16 | 1.6329 | 44 | 16 | 1'6596 | 44 | 16 | 1.6854 | 44 | 16 | 1.7104 | 4 |
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| 22 | | | 24 | | | | | | 24 | 1.7120 | 8 |
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| 24 26 | 1.6352 | 34 | 26 | 1.6617 | 34 | 26 | 1.6875 | 34 | 26 | 1.7124 | |
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| 24 26 28 30 32 34 36 38 40 42 | 1.6352 1.6356 1.6361 1.6365 1.6370 1.6374 1.6383 1.6388 | 34 32 30 28 26 24 22 20 18 | 26 28 30 32 34 36 38 40 42 | 1.6617 1.6622 1.6626 1.6631 1.6635 1.6644 1.6648 1.6652 | 34 32 30 28 26 24 22 20 18 | 26 28 30 32 34 36 38 40 42 | 1.6875 1.6879 1.6884 1.6888 1.6892 1.6896 1.6900 1.6905 1.6909 | 34 32 30 28 26 24 22 20 18 | 28, 30, 32, 34, 36, 38, 40, 42, | 1·7128 1·7183 1·7187 1·7141 1·7145 1·7149 1·7158 1·7157 | 3 2 2 2 2 2 2 1 |
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| 24 26 28 30 32 34 36 38 40 42 44 46 48 | 1.6352 1.6356 1.6361 1.6365 1.6370 1.6374 1.6383 1.6388 1.6392 1.6397 1.6401 | 34 32 30 28 26 24 22 20 18 16 14 12 | 26 28 30 32 34 36 38 40 42 44 46 48 | 1.6617 1.6622 1.6626 1.6635 1.6639 1.6644 1.6648 1.6652 1.6657 1.6661 | 34 32 30 28 26 24 22 20 18 16 14 | 26 28 30 32 34 36 38 40 42 44 46 48 | 1.6875 1.6879 1.6884 1.6888 1.6892 1.6896 1.6905 1.6909 1.6913 1.6917 1.6921 | 34 32 30 28 26 24 22 20 18 16 14 | 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, | 1·7128 1·7137 1·7141 1·7145 1·7149 1·7153 1·7157 1·7161 1·7165 1·7169 | 2 2 2 2 2 2 2 2 2 1 1 1 |
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| 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 | 1.6352 1.6356 1.6361 1.6365 1.6374 1.6379 1.6383 1.6382 1.6392 1.6397 1.6401 1.6406 1.6410 | 34 32 30 28 26 24 22 20 18 16 14 12 10 8 | 26 28 30 32 34 36 38 40 42 44 46 48 50 52 | 1'6617 1'6622 1'6626 1'6631 1'6635 1'6644 1'6648 1'6657 1'6657 1'6665 1'6667 1'6674 | 34 32 30 28 26 24 22 20 18 16 14 12 10 8 | 26 28 30 32 34 36 38 40 42 44 46 48 50 50 | 1:6875 1:6879 1:6884 1:6888 1:6892 1:6896 1:6900 1:6909 1:6913 1:6917 1:6921 1:6926 1:6930 | 34 32 30 28 26 24 22 20 18 16 14 12 10 8 | 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52, | 1-7128 1-7183 1-7187 1-7141 1-7145 1-7153 1-7157 1-7161 1-7165 1-7169 1-7173 1-7177 | 33 32 22 22 22 21 11 11 |
| 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 | 1.6352 1.6356 1.6361 1.6365 1.6374 1.6379 1.6383 1.6388 1.6392 1.6397 1.6406 1.6410 1.6414 | 34 82 30 28 26 24 22 20 18 16 14 12 8 | 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 | 1'6617 1'6622 1'6626 1'6631 1'6635 1'6635 1'6644 1'6652 1'6657 1'6661 1'6670 1'6674 | 34 32 30 28 26 24 22 20 18 16 14 12 10 8 | 26 28 30 82 84 86 88 40 42 44 46 48 50 52 54 | 1:6875 1:6879 1:6884 1:6888 1:6892 1:6906 1:6909 1:6903 1:6913 1:6917 1:6921 1:6926 1:6934 | 34 32 30 28 26 24 22 20 18 16 14 12 10 8 | 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52, 54, | 1·7128 1·7183 1·7187 1·7141 1·7145 1·7157 1·7167 1·7166 1·7169 1·7173 1·7177 1·7181 | 38 38 22 22 22 22 21 11 11 11 |
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| 36 | 1.7266 | 24 | 36 | 1.7501 | 24 | 86 | 1.7727 | 24 | 36 | 1.7944 | 1 5 |
| 38 40 | 1.7270 | 22 | 38 40 | 1.7505 | | 38 40 | | 22 20 | 38 40 | | 2 |
| 42 | 1 7278 | 18 | 42 | 1.7518 | 18 | 42 | | 18 | 42 | 1.7955 | 1 |
| 44 | 1.7282 | 16 | 44 | 1.7516 | 16 | 44 | | 16 | 44 | 1.7958 | 1 |
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| 1.8843 | 50 | 10 | 1.9001 | 50 | 10 | 1.9147 | 50 | | | 5 |
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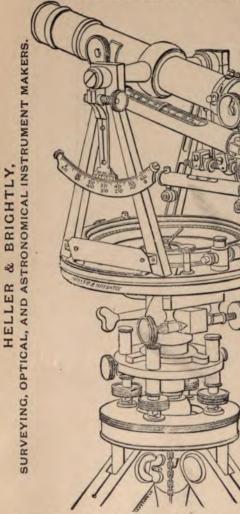
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